Getting to the Core

Grade 8 Unit of Study

TEACHER EDITION

Roller Coaster Physics

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Santa Ana Unified School District Common Core Unit Planner-Literacy

<table>
<tr><td>Unit Title:</td><td colspan="2">Roller Coaster Physics</td></tr>
<tr><td>Grade Level/Course:</td><td>8th grade/Science</td><td>Time Frame: 15 days</td></tr>
<tr><td>Big Idea (Enduring Understandings):</td><td colspan="2">Energy plays an important role in manufacturing design.</td></tr>
<tr><td>Essential Questions:</td><td colspan="2">
• What do all traditional roller coasters have in common as their energy source?
• How is a roller coaster able to travel up hills and do loops without an engine?
• What forces create a roller coaster ride?
• What types of injuries might a person sustain on a roller coaster ride?
• What forces play a role in injuries sustained from roller coaster rides?
• How do roller coaster engineers and park safety managers address the excessive G-forces exerted by roller coasters on its riders?
• Are roller coasters safe or unsafe?
• What is the engineering design process?
• How do you use the engineering process to design and create a roller coaster that fits within budget and design specifications?
</td></tr>
<tr><td colspan="3">Instructional Activities: Activities/Tasks</td></tr>
<tr><td colspan="3">
<u>Lesson 1</u>
Extended Anticipatory Guide
Complex Text: Article: Roller Coaster History
Read 1 – Activity: Teacher reads aloud
Read 2 – Activity: Students re-read silently
Read 3 – Activity: Students read with a pencil with elbow partner
Read 4 – Activity: Students create Thinking Map
</td></tr>
</table>

Lesson 2

Question Generator

Energy Exploration Lab

Complex Text: Article: Kinetic and Potential Energy

- **Read 1** – Activity: Students read silently
- **Read 2** – Activity: A reads aloud to B; B summarizes with clarifying bookmarks
- **Read 3** – Activity: B reads aloud to A; A summarizes with clarifying bookmarks

Lesson 3

Complex Text: Articles: Batman The Ride, GhostRider, Phantom's Revenge, X2

- **Read 1** – Activity: In Expert Groups, students read their article silently
- **Read 2** – Activity: In Expert Groups, students read with a pencil with a partner
- **Read 3** – Activity: In Expert Groups, students discuss, then fill in Jigsaw Matrix
- **Read 4** – Activity: In Base Groups students read/share info from their Matrix; group members fill in Jigsaw Matrix/ask clarifying questions

Inertia Investigation

Stay in the Loop Demonstration

Lesson 4

Complex Text: Common Injuries Related to Roller Coaster Riding Matrix

- **Read 1** – Activity: Students read through Matrix silently
- **Read 2** – Activity: Students re-read with a pencil
- **Read 3** – Activity: Students create 3 questions from their reading
- **Read 4** – Activity: A asks B questions, B reads Matrix to answer
- **Read 5** – Activity: B asks A questions, A reads Matrix to answer

Complex Text: Articles: Amusement Ride Safety Tips, Ride Safety in the US, Design and Technology, G-Forces

- **Read 1** – Activity: Students skim their assigned article and fill in Prediction Matrix; Students share their predictions/questions with group
- **Read 2** – Activity: Students read their articles silently with a pencil
- **Read 3** – Activity: Write summary statements, share and write summary statements on other students articles

Vocabulary Review Jigsaw

<u>Lesson 5</u>

Marshmallow Design Challenge

Complex Text: Graphic of The Engineering Design Process, Roller Coaster Challenge Letter

- **Read 1** – Activity: Teacher reads through design process graphic aloud/discusses with students
- **Read 2** – Activity: Students use design process graphic to reflect on marshmallow challenge
- **Read 3** – Activity: Students read silently while teacher reads challenge letter aloud (intro to project)

<u>Lessons 6-7</u>

Roller Coaster Build

Project Proposal

Peer Review

Complex Text: Model Guidelines, Proposal Guidelines, Design and Performance Data and Score Sheet, Budget Analysis, Proposal Questions, Proposal Rubric

- **Read 1** – Activity: Teacher reads through the above listed criteria sheets/proposal pages at appropriate times during the project
- **Read 2** – Activity: Students refer to the above for guidance/recording data, etc during project
- **Read 3** – Activity: Students refer back to the appropriate sheets as they write up their final proposal and reflections

<table>
<tr><td>21st Century Skills:</td><td colspan="2">Learning and Innovation:
☒ Critical Thinking & Problem Solving ☒ Communication & Collaboration ☒ Creativity & Innovation
Information, Media and Technology:
☒ Information Literacy ☒ Media Literacy ☒ Information, Communications & Technology Literacy</td></tr>
<tr><td>Essential Academic Language:</td><td>Tier II:
Proposal Innovative Trials Docent
Relationship Monumental Constraints
Data Diverge Statistics
Graph Scenic Restraints
Criteria Budget Structure
Performance Peer review Evaluate</td><td>Tier III:
Energy Gravity Centripetal force Inertia
Kinetic energy G-force Friction Force
Potential energy Acceleration Corkscrew track Motion
Tubular steel track Conservation of energy Hematoma
Aneurysm Whiplash Fracture Air time
Weightlessness Engineering design process</td></tr>
<tr><td colspan="2">What pre-assessment will be given?
Extended Anticipatory Guide – students will agree or disagree with statements</td><td>How will pre-assessment guide instruction?
Statements in the Extended Anticipatory Guide are directly related to concepts being developed in the unit. Student responses to anticipatory guide will inform instructor to students' prior knowledge of physical science concepts experienced in this unit, which in turn informs teacher of students that may need additional support or be able to extend their learning. By the end of the unit, the students will have experienced activities that support understanding of pieces of complex text related to the statements. Students will then revisit the Extended Anticipatory Guide and use new found knowledge to agree/disagree with each statement, this time supporting their decision by citing evidence.</td></tr>
<tr><td colspan="3">End of Unit Performance Task:
Students will design and build a roller coaster that meets certain parameters. Students will apply physical science concepts of potential/kinetic energy and centripetal/gravitational forces in their coaster design. Students will present their coaster orally and will also prepare a written proposal to submit to an amusement park.</td></tr>
<tr><td colspan="2">Standards</td><td>Assessment of Standards (include formative and summative)</td></tr>
<tr><td colspan="2">Content Standard(s):
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1. Construct and interpret graphical displays of data to</td><td>(F) Extended Anticipatory Guide pre-assessment of concepts to be learned in this unit
(F) Thinking Map – complex text on history of roller coasters, discussion of what makes all roller coasters work
(F) Question Generator – allows teacher to see what questions</td></tr>
</table>

describe the relationships of kinetic energy to the mass of an object and to the speed of an object. **MS-PS3-2.** Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. **PS2.A: Forces and Motion** •For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). •The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. **PS2.B: Types of Interactions** •Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. **PS3.A: Definitions of Energy** •Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	students have about roller coasters and how they work (F) Energy Exploration Lab – students explore and make some conclusions about energy conservation, then read about PE and KE and relate to the lab (F) Jigsaw Matrix – students read about roller coasters and compare/contrast thrilling aspects of the coasters (F) Inertia Investigation – students investigate basic principles of inertia and how these relate to roller coasters, along with g-force, acceleration and centripetal force – by the end of the lesson, students should be able to use academic language to explain how roller coasters work (F) Injury Matrix and safety articles – students should be able to relate inertia and forces to safety issues (F) Vocabulary Review Jigsaw – teacher can see how well students have learned the academic language presented so far – informs teacher of students that may need more assistance as they move into the next phase of the unit (F) Marshmallow Design Challenge/Engineering Design Process – how well have students internalized the concepts of engineering design – informs teacher of students that may need more assistance as they move into the design/build portion of the unit (S) Written Proposal (S) Proposal Rubric (S) Presentation/Peer Review

•A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** •When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** •A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. •There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. •Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. •Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** •Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. •The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

Common Core Learning Standards Taught and Assessed (*include one or more standards for one or more of the areas below. Please write out the complete text for the standard(s) you include.)*	**What assessment(s) will be utilized for this unit?** *(include the types of both formative assessments (**F**) that will be used throughout the unit to inform your instruction and the summative assessments (**S**) that will demonstrate student mastery of the standards.)*	**What does the assessment tell us?**
Bundled Reading Literature Standard(s):		
Bundled Reading Informational Text Standard(s): **RST.6-8.1.** Cite specific textual evidence to support analysis of science and technical texts **RST.6-8.3.** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks **RST.6-8.7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)	(F) Extended Anticipatory Guide (F) Thinking Map – complex text on history of roller coasters, discussion of what makes all roller coasters work (F) Question Generator – allows teacher to see what questions students have about roller coasters and how they work (F) Energy Exploration Lab – students explore and make some conclusions about energy conservation, then read about PE and KE and relate to the lab (F) Jigsaw Matrix – students read about roller coasters and compare/contrast thrilling aspects of the coasters (F) Injury Matrix and safety articles – students should be able to relate inertia and forces to safety issues (F) Vocabulary Review Jigsaw – teacher can see how well students have learned the academic language presented so far the unit (S) Written Proposal (S) Proposal Rubric	Can students cite evidence and draw conclusions? What questions students have about roller coasters? Can students relate reading in articles to lab experience? Can students find commonalities? Can students relate reading in articles to real life experiences? Informs teacher of students that may need more assistance with academic language How well can students follow specific guidelines?

Common Core Learning Standards Taught and Assessed (*include one or more standards for one or more of the areas below. Please write out the complete text for the standard(s) you include.)*	**What assessment(s) will be utilized for this unit?** *(include the types of both formative assessments (***F***) that will be used throughout the unit to inform your instruction and the summative assessments (***S***) that will demonstrate student mastery of the standards.)*	**What does the assessment tell us?**
Bundled Writing Standard(s): **WHST.6-8.4.** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience **WHST.6-8.8.** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation **WHST.6-8.9.** Draw evidence from informational texts to support analysis, reflection, and research	(F) Thinking Map – complex text on history of roller coasters, discussion of what makes all roller coasters work (F) Question Generator (F) Energy Exploration Lab – students explore and make some conclusions about energy conservation, then read about PE and KE and relate to the lab (F) Inertia Investigation – students investigate basic principles of inertia and how these relate to roller coasters (F) Injury Matrix and safety articles – students should be able to relate inertia and forces to safety issues (F) Marshmallow Design Challenge Reflection	Can students choose an effective thinking map that reflects their thinking? What questions students have about roller coasters and how they work? How well can students illustrate their work/thinking? How well can students express what they observed in investigation? Can students write summary statements about their reading? How well have students internalized the concepts of

	(S) Written Proposal (S) Proposal Rubric (S) Extended Anticipatory Guide	engineering design? How well did students present their findings in written format, following the proposal rubric? How well did individual students grasp physical science concepts and can they cite evidence to support?
Bundled Speaking and Listening Standard(s): **SL.8.1.** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly **SL.8.4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation **SL8.5.** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest	(F) Thinking Map – complex text on history of roller coasters, discussion of what makes all roller coasters work (F) Question Generator – allows teacher to see what questions students have about roller coasters and how they work (F) Energy Exploration Lab – students explore and make some conclusions about energy conservation, then read about PE and KE and relate to the lab (F) Jigsaw Matrix – students read about roller coasters and compare/contrast thrilling aspects of the coasters (F) Inertia Investigation – students investigate basic principles of inertia and how these relate to roller coasters, along with g-force, acceleration and centripetal force – by the end of the lesson, students should be able to use academic language to explain how roller coasters work (F) Injury Matrix and safety articles – students	All activities: How well can students collaborate and reach consensus? How well can they express their thinking? How well can they defend their claims and findings using evidence to support? How well can they present their project and express their findings in the peer review process?

	should be able to relate inertia and forces to safety issues (F) Vocabulary Review Jigsaw – teacher can see how well students have learned the academic language presented so far – informs teacher of students that may need more assistance as they move into the next phase of the unit (F) Marshmallow Design Challenge/Engineering Design Process – how well have students internalized the concepts of engineering design – informs teacher of students that may need more assistance as they move into the design/build portion of the unit (S) Presentation/Peer Review	
Bundled Language Standard(s): **L.8.1.** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking **L.8.2.** Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing **L.8.3.** Use knowledge of language and its conventions when writing, speaking, reading, or listening **L.8.4.** Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 8 reading and content, choosing flexibly from a range of strategies **L.8.6.** Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression **ELD Standards:** **Part IC-9:** Express information and ideas in formal oral presentations on academic topics **Part IC-10:** Write literary and informational texts to present, describe, and explain ideas and information, using appropriate technology **Part IC-11:** Justify opinions or persuade others by making connections and distinctions between ideas and texts and articulating		

sufficient, detailed, and relevant textual evidence or background knowledge, using appropriate register.		

Resources/ Materials:	**<u>Complex Texts to be used</u>** **Informational Text(s) Titles:** Roller Coaster History Kinetic and Potential Energy Batman The Ride, GhostRider, Phantom's Revenge, X2 Common Injuries Related to Roller Coaster Riding Matrix Amusement Ride Safety Tips, Ride Safety in the US, Design and Technology, G-Forces Graphic of The Engineering Design Process, Roller Coaster Challenge Letter Model Guidelines, Proposal Guidelines, Design and Performance Data and Score Sheet, Budget Analysis, Proposal Questions, Proposal Rubric **Literature Titles: N/A** **Primary Sources: N/A** **Media/Technology:** Optional access to computers for online activities/research extension **Other Materials:** Roller coaster track templates license – paperrollercoasters.com Structural and track pieces printed on cardstock by district printshop 1" pipe insulation Glass marbles Tape Cardboard bases Spaghetti Marshmallows Masking tape Bucket Teacher/school provides: scissors, rulers/meter sticks, cups, pennies, string, timers (can use cell phones or timers from FOSS Force and Motion kits if school does not have)

<table>
<tr><td>Interdisciplinary Connections:</td><td colspan="2">Cite several interdisciplinary or cross-content connections made in this unit of study (i.e. math, social studies, art, etc.)
Math – cost analysis of coaster in proposal, calculations of speed
Health – consideration of health issues that are exacerbated by riding roller coasters (eg. brain injury, back and neck injuries) and safety harnesses to prevent accidental ejection from ride
Social studies – history of roller coasters</td></tr>
<tr><td>Differentiated Instruction:</td><td>Based on desired student outcomes, what instructional variation will be used to address the needs of English Learners by language proficiency level?

Cooperative groups – teacher groups students strategically
Pair share and group talk/collaboration
Multiple opportunities to speak
Teacher reads and models
Hands-on inquiry activities
Teacher demonstrations
Video
Interactive notes with visuals
Articles at different reading levels
Partnered reading
Visuals</td><td>Based on desired student outcomes, what instructional variation will be used to address the needs of students with special needs, including gifted and talented?

Special Needs:
IEPs are read by teacher and specific needs for individual students are addressed throughout the unit
Cooperative groups – teacher groups students strategically
Pair share and group talk/collaboration
Multiple opportunities to speak
Teacher reads and models
Hands-on inquiry activities
Teacher demonstrations
Video
Interactive notes with visuals
Articles at different reading levels
Partnered reading
Visuals
GATE:
Less/no guided practice
Open-ended Thinking Map choice
May want to add more complicated quantitative data collection during investigations and allow students to extend investigation
Read more than one article
Read higher level articles
Take leadership role in Expert and/or Base Group
Show the TED talk on the Marshmallow Challenge
Blue prints in final task drawn to scale and include measurements in centimeters</td></tr>
</table>

SAUSD Common Core Science 8 Unit – Roller Coaster Physics

Contents:
Big Idea – Energy plays an important role in manufacturing design.

SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Day: 1** **Lesson: 1**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 1 class period** **Date:**
Big Idea: Energy plays an important role in manufacturing design. **Essential Question** – What do all traditional roller coasters have in common as their energy source?		
Common Core and Next Generation Science Standards	**NGSS: Disciplinary Core Ideas** PS2.B: Types of Interactions •Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. **Reading Standards for Literacy in Science and Technical Subjects** RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table) **Writing Standards for Literacy in Science and Technical Subjects** WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research **Speaking and Listening Standards (ELA)** SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation	
Materials/ Resources/ Lesson Preparation	"SR" refers to Student Resource – all located in student handbooks "TR" refers to Teacher Resource – all located in teacher handbook/CD TR 1.1 Roller Coasters Interactive Power Point SR 1.1 Quick Write and Round Robin on Roller Coasters SR 1.2 Extended Anticipatory Guide SR 1.3 Article: Roller Coaster History SR 1.4 Thinking Map – The History of Roller Coasters	

Objectives		**Content:** Students will create a Thinking Map that will organize the content from the reading, “The History of Roller Coasters” and look for the energy source that is similar in all roller coasters.	**Language:** Students will complete a quick write and orally share their statements with a team. Students will read an article and organize the content into Thinking Map.
Depth of Knowledge Level		☐ **Level 1: Recall** ☐ **Level 2: Skill/Concept** ☒ **Level 3: Strategic Thinking** ☐ **Level 4: Extended Thinking**	
College and Career Ready Skills		☒ **Demonstrating independence** ☒ **Building strong content knowledge** ☒ **Responding to varying demands of audience, task, purpose, and discipline** ☒ **Comprehending as well as critiquing** ☐ **Valuing evidence** ☐ **Using technology and digital media strategically and capably** ☐ **Coming to understand other perspectives and cultures**	
Common Core Instructional Shifts		☒ **Building knowledge through content-rich nonfiction texts** ☒ **Reading and writing grounded from text** ☒ **Regular practice with complex text and its academic vocabulary**	
Academic Vocabulary (Tier II & Tier III)		**KEY WORDS ESSENTIAL TO UNDERSTANDING**	**WORDS WORTH KNOWING**
	TEACHER PROVIDES SIMPLE EXPLANATION		
	STUDENTS FIGURE OUT THE MEANING	innovative monumental diverge evolution scenic	corkscrew track tubular steel coasters
Pre-teaching Considerations		Students will need to be arranged in teams of 4 – identify students as A (shortest first name), B, C, D May want to review Thinking Maps The interactive PPT will guide teacher and students through entire lesson – be sure to preview and familiarize yourself with the flow of the lesson Teacher will need a document camera to demonstrate “reading with a pencil”	

Lesson Delivery		
Instructional Methods		**Check method(s) used in the lesson:** ☒ **Modeling** ☒ **Guided Practice** ☒ **Collaboration** ☒ **Independent Practice** ☐ **Guided Inquiry** ☐ **Reflection**
Lesson Continuum	**Lesson Opening**	**Preparing the Learner** Prior Knowledge, Context, and Motivation: **Quick Write** 1. The teacher will begin by asking for a show of hands – How many of you have ever ridden a roller coaster? OR The teacher may choose to describe their own roller coaster experience. 2. Have students open their handbook to SR 1.1 Quick Write and Round Robin on Roller Coasters. 3. The teacher will read the Quick Write prompt out loud to the class. 4. The teacher will allow 1-2 minutes of think time, followed by 2-3 minutes of writing time. (Students should be reminded to answer ONE of the questions, and to write in the space provided) **Round Robin** 1. Students should be seated in groups of 4. Student with the shortest first name (A) gets to go first. 2. Student A starts by sharing out their experience while other students listen. Student B goes next, then C, then D. Other students may not interrupt or comment until everyone has shared their experience. 3. Teacher must circulate as students are working to ensure that ALL students are speaking and others are actively listening according to the round robin protocol.
	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Interacting with the concept/text:** **Extended Anticipatory Guide** 1. Have students open their handbooks to SR 1.2 Extended Anticipatory Guide. Have students read each statement and ONLY check "agree" if they agree with the statement as it is written or "disagree" if they do not, in the first column (Day 1). If needed, teacher can read each statement aloud. They will finish the guide as a post assessment at the end of Day 14. Circulate to ensure that students are only checking under Day 1. **NOTE**: If students ask what words mean, tell them to answer the best they can – don't tell them any meanings at this time. This will serve as a pre-assessment for you to know where students are.

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**History of Roller Coasters** 1. Have students open their handbooks to SR 1.3 Article: Roller Coaster History. 2. Students individually silently read the article, focusing on understanding what they are reading, and not necessarily on finishing the article. Emphasize that there will be time to finish reading so students do not stress. 3. Students can then re-read the article aloud with a neighbor, alternating reading each paragraph aloud to each other. As they read together, students should mark ideas that focus on the question, "How have roller coasters evolved or changed over time?" ****NOTE**: Model the skill: **Before** students re-read with a neighbor, the teacher models finding the first roller coaster (paragraph 1), using document camera, showing the students how they came up with it and modeling "reading with a pencil" to underline key information and annotate margins. They will then have the students read the next paragraph "with a pencil," looking for how the first design changed. Once the teacher is confident the students understand, the students are released to find the next innovations as partners. 4. The students will then work with the other students in their group to create a Thinking Map about the reading. The teacher should leave the Map choice up to the students to engage them in thinking about how to organize information. If students are unfamiliar with the Maps, display models of maps previously created to help students see how material can be organized using the maps. It is okay if students pick different Maps. 5. Have students create a Frame on their maps. They should cite, in complete sentences, which paragraphs they got their information from to create the map. 6. Teacher circulates the room, offering guidance where needed.	**Students Who Need Additional Support** • Cooperative groups for immediate feedback. • Multiple opportunities to speak • Students read at own pace and re-read with a partner for support. • Model Maps by showing examples of how they have been used. **Accelerated Learners:** • Reduce guided practice when students are selecting thinking map format • Peer grouping to deepen thinking and match pace • Multiple citations in framework

		7. Five minutes before the end of class, have students focus on the conclusion question printed on the bottom of the thinking map: "Compare all the coasters you read about today." What do all the coasters have in common with respect to what makes them move? (At this point in time, the students should be able to at least state that all the coasters started by going downhill – if they don't say gravity, don't dwell on it at this point) **NOTE**: Students could answer this question on an exit slip and turn it in as they are leaving class.	

Lesson Reflection	
Teacher Reflection Evidenced by Student Learning/ Outcomes	

Roller Coasters

Day 1

Quick Write/Round-Robin

Anticipatory Guide

History of Roller Coasters

Quick Write

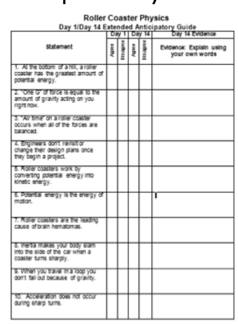
Choose ONE of the following prompts:

* Think of your favorite roller coaster or amusement park ride. Describe where it is, when you rode on it and why it is your favorite.
* What is the scariest roller coaster you have ever heard of? Describe where it is and what makes it so terrifying.

Round-Robin

* Working in teams of four, take turns reading your quick write statements to the group.
* The person with the shortest first name (student A) goes first, then B, C and D.
* Everyone shares—even if a previous team member had the same response.
  * *Example: "My favorite roller coaster is the same as ______, but I like it for a different reason…."*
* Others may not interrupt or comment until everyone has shared their experience.

Anticipatory Guide



Roller Coaster Physics

Day 1/Day 14 Extended Anticipatory Guide

Statement	Day 1		Day 14		Day 14 Evidence
	Agree	Disagree	Agree	Disagree	Evidence: Explain using your own words
1. At the bottom of a hill, a roller coaster has the greatest amount of potential energy.					
2. "One G" of force is equal to the amount of gravity acting on you right now.					
3. "Air time" on a roller coaster occurs when all of the forces are balanced.					
4. Engineers don't revisit or change their design plans once they begin a project.					
5. Roller coasters work by converting potential energy into kinetic energy.					
6. Potential energy is the energy of motion.					
7. Roller coasters are the leading cause of brain hematomas.					
8. Inertia makes your body slam into the side of the car when a coaster turns sharply.					
9. When you travel in a loop you don't fall out because of gravity.					
10. Acceleration does not occur during sharp turns.					

Article: History of Roller Coasters

* Step 1: Read silently. Don't worry if you don't' finish.
* Step 2: Re-read aloud with a partner, alternating each paragraph. Think about "How have roller coasters evolved or changed over time?"
* Step 3: Create a Thinking Map that best organizes the events in the article.
* Step 4: Add a "Frame of Reference" to cite where you got your information.

Article Conclusion

* Final task for today!

Compare all the coasters you read about today. What do all the coasters have in common with respect to what makes them move?

Name ___________________________________

Quick Write and Round-Robin on Roller Coasters

Quick Write

Choose ONE of the following questions and write your answer using complete sentences in the box below:

1. Think of your favorite roller coaster or amusement park ride. Describe where it is, when you rode on it and why it is your favorite.
2. What is the scariest roller coaster you have ever heard of? Describe where it is and what makes it so terrifying.

Round-Robin

- Working in teams of four, take turns reading your quick write statements to the group.
- The person with the shortest first name (student A) goes first, then B, C and D.
- Everyone shares—even if a previous team member had the same response.
- Others may not interrupt or comment until everyone has shared their experience.

Name ___________________________________

Roller Coaster Physics

Day 1/Day 14 Extended Anticipatory Guide

Statement	Day 1		Day 14		Day 14 Evidence
	Agree	Disagree	Agree	Disagree	Evidence: Explain using your own words
1. At the bottom of a hill, a roller coaster has the greatest amount of potential energy.					
2. "One G" of force is equal to the amount of gravity acting on you right now.					
3. "Air time" on a roller coaster occurs when all of the forces are balanced.					
4. Engineers don't revisit or change their design plans once they begin a project.					
5. Roller coasters work by converting potential energy into kinetic energy.					
6. Potential energy is the energy of motion.					
7. Roller coasters are the leading cause of brain hematomas.					
8. Inertia makes your body slam into the side of the car when a coaster turns sharply.					
9. When you travel in a loop you don't fall out because of gravity.					
10. Acceleration does not occur during sharp turns.					

Name ____________________________

Roller Coaster History

1. Roller coasters have a long, fascinating history. The direct ancestors of roller coasters were monumental ice slides -- long, steep wooden slides covered in ice, some as high as 70 feet -- that were popular in Russia in the 16th and 17th centuries. Riders shot down the slope in sleds made out of wood or blocks of ice, crash-landing in a sand pile.

2. Coaster historians diverge on the exact evolution of these ice slides into actual rolling carts. The most widespread account is that a few entrepreneurial Frenchmen imported the ice slide idea to France. The warmer climate of France tended to melt the ice, so the French started building waxed slides instead, eventually adding wheels to the sleds.

3. In 1817, the Russes a Belleville (Russian Mountains of Belleville) became the first roller coaster where the train was attached to the track (in this case, the train axle fit into a carved groove). The French continued to expand on this idea, coming up with more complex track layouts, with multiple cars and all sorts of twists and turns.

4. The first American roller coaster was the Mauch Chunk Switchback Railway, built in the mountains of Pennsylvania in the mid-1800s. The track, originally built to send coal to a railway, was reconfigured as a "scenic tour." For one dollar, tourists got a leisurely ride up to the top of the mountain followed by a wild, bumpy ride back down.

5. Over the next 30 years, these scenic rides continued to thrive and were joined by wooden roller coasters similar to the ones we know today. These coasters were the main attraction at popular amusement parks throughout the United States, such as Kennywood Park in Pennsylvania and Coney Island in New York. By the 1920s, roller coasters were in full swing, with some 2,000 rides in operation around the country.

6. With the Great Depression and World War II, roller coaster production declined, but a second roller coaster boom in the 1970s and early 1980s revitalized the amusement park industry. This era introduced a slew of innovative tubular steel coasters. Some of the most popular ride variations -- such as the curving corkscrew track -- saw their heyday around this time.

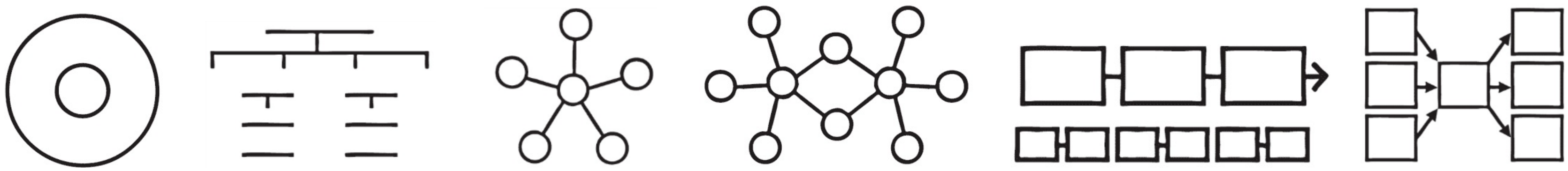
Name _____________________________

Name ____

Thinking Map - The History of Roller Coasters

Step 1: After reading the article, "The History of Roller Coasters," number the events that lead to the creation of a modern day roller coaster.

Step 2: Working with your team, create a Thinking Map that best organizes the events listed in the article.



____

CONCLUSION: Compare all the coasters you have read about today. What do all the coasters have in common with respect to what makes them move?

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SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Days: 2-3** **Lesson: 2**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 2 class periods** **Date:**
Big Idea: Energy plays an important role in manufacturing design **Essential Question:** How is a roller coaster able to travel up hills and do loops without an engine?		
Common Core and Next Generation Science Standards	**NGSS: Performance Expectations** **MS-PS3-1.** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. **MS-PS3-2.** Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **NGSS: Disciplinary Core Ideas** **PS3.A: Definitions of Energy** •Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. •A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** •When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** •A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. •There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. •Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. •Models of all kinds are important for testing solutions.	

<table>
<tr><td></td><td colspan="2">Reading Standards for Literacy in Science and Technical Subjects:
RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts
RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks

Writing Standards for Literacy in Science and Technical Subjects:
WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience
WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research

Speaking and Listening Standards (ELA):
SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly
SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation
SL8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest</td></tr>
<tr><td>Materials/ Resources/ Lesson Preparation</td><td colspan="2"><u>Day 2</u>
1" pipe insulation, cut in half lengthwise x 3' long (10 pieces)
1" pipe insulation, cut in half lengthwise x 6' (1 piece)
5/8" glass marbles (1 per group)
timers (1 per group)
rulers or meter sticks (1 per group)
TR 2.1 Investigating Energy interactive ppt
SR 2.1 Question Generator
SR 2.2 Energy Exploration Lab

<u>Day 3</u>
TR 2.3 Energy interactive ppt
SR 2.3 Lined Note Paper
SR 2.4 Article on PE and KE
SR 2.5 Clarifying Bookmarks</td></tr>
<tr><td>Objectives</td><td>Content:
Students will investigate and be able to describe different types of energy – kinetic and potential – and their relationship to the conservation of energy.</td><td>Language:
In pairs students will write observations, read complex text, listen and respond, then construct their own definitions of potential and kinetic energy.</td></tr>
</table>

Depth of Knowledge Level		**☒ Level 1: Recall** **☒ Level 2: Skill/Concept** **☒ Level 3: Strategic Thinking** **☐ Level 4: Extended Thinking**	
College and Career Ready Skills		**☒ Demonstrating independence** **☒ Building strong content knowledge** **☒ Responding to varying demands of audience, task, purpose, and discipline** **☐ Comprehending as well as critiquing** **☒ Valuing evidence** **☐ Using technology and digital media strategically and capably** **☐ Coming to understand other perspectives and cultures**	
Common Core Instructional Shifts		**☒ Building knowledge through content-rich nonfiction texts** **☒ Reading and writing grounded from text** **☒ Regular practice with complex text and its academic vocabulary**	
Academic Vocabulary (Tier II & Tier III)		**KEY WORDS ESSENTIAL TO UNDERSTANDING**	**WORDS WORTH KNOWING**
	TEACHER PROVIDES SIMPLE EXPLANATION	Energy conservation of energy	
	STUDENTS FIGURE OUT THE MEANING	potential energy kinetic energy	
Pre-teaching Considerations		**Before the unit:** • Group students into 10 teams of 3-4 • The interactive PPTs will guide teacher and students through entire lesson each day– be sure to preview and familiarize yourself with the flow of each lesson • Videos are online and do not load very quickly. Teachers should open each video before class in separate browser pages to let the videos buffer so viewing is smooth. • Prepare lab materials for each group – 1 marble, 1 stopwatch (can use cell phones or timers from FOSS kit), 1 3ft section of tubing, 1 ruler/meter stick • You have one 6’ section of insulation “track” – this will allow students to extend their investigation to include loops if they so desire	

<table>
<tr><th colspan="3">Lesson Delivery</th></tr>
<tr><td colspan="2">Instructional Methods</td><td>Check method(s) used in the lesson:
☐ Modeling ☐ Guided Practice ☒ Collaboration
☐ Independent Practice ☒ Guided Inquiry ☒ Reflection</td></tr>
<tr><td>Lesson Continuum</td><td>Lesson Opening</td><td><u>Day 2: Investigating Energy</u>
Preparing the Learner
Prior Knowledge, Context, and Motivation:

1. After reviewing their Thinking Map conclusion (SR 1.4) – Have students review with what they determined the roller coasters had in common throughout history (had to go downhill). They should take 20-30 seconds to elaborate/clarify then paraphrase with their elbow partners and then share out what causes this “energy source.” Have students share what their partner said by paraphrasing.
NOTE: Accept all answers at this point. Have students try and explain WHY they think that all of the coasters have been powered by that energy source. Hopefully you will get at least one student to say the word “gravity.” <u>Do not explain the concept of gravity yet</u>.

2. Have students watch 1-2 minutes of “Top 10 Steel Roller Coasters” (This is a 10 minute video – if there is extra time later, this video might be enjoyable to watch at the end of the period or lesson)

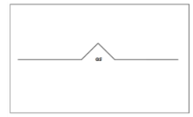
3. Have students turn to SR 2.1 in their handbooks. On the next slide, show students the statement, “Roller coasters work by converting Potential Energy into Kinetic Energy.” In their groups, have them generate as many questions that relate to the statement and the video clip that they watched as they can in 5 minutes and record these questions on their paper. Remind students not to judge any of the questions. Do not stop to answer any of the questions at this point.

4. Ask students to choose their best question that most closely relates to the question focus on PPT slide 4. Share out 3-5 questions, and use those questions to segue into the inquiry lab activity. You may need to give students sentence frames, “The question that most interests us as a team is…” or “Our most interesting question is the same as the last team, but we also are interested in…”</td></tr>
</table>

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Day 2: Investigating Energy** **Interacting with the concept/text:** Students in groups of 4 will have the opportunity to investigate how starting height affects rebound height. Use TR 2.1 Investigating Energy interactive ppt to guide lesson. 1. Have students turn to SR 2.2 Energy Exploration. 2. Explain that they will be forming 4 different models of roller coasters. Use the power point slide to go through the following guidelines: • The marble cannot leave the foam track in order for the trial to be recorded. • You must collect some type of quantitative data (numbers) for the trial to be recorded. • The foam track cannot be moved while the marble is moving. • You must release the marble only, not push it. 3. You will probably want to model how to hold the foam and drop the marble into a simple U shape. 4. You will need to model how to fill in the lab sheet and emphasize what an observation is (something they can see, describe, measure, etc – it is not what they infer) 5. As students begin their exploration, circulate and discuss the observations that the students are finding. You may want to ask individual groups guiding questions such as: • *How do you get a marble to roll on a track?* • *Can you get the marble to roll up a new hill?* • *Does the drop angle affect the height that the marble goes up the hill?* • *Does the height it is dropped from affect the height it goes up the hill?* • *Why doesn't the marble go as high up the hill as it was dropped at?* • *Why does the marble eventually stop moving?* • *What type of quantitative data did you choose to gather?* • *Why did you choose (drop height, angle, rebound height, time, etc)* If students ask if they can try a loop, let them use the 6' track section.	**Students Who Need Additional Support** • Pair-share to practice speaking and provide immediate feedback • Hands-on inquiry to contextualize • Video clip to engage and contextualize • Interactive notes with visuals to clarify language • Teacher proximity for immediate feedback • Peer grouping for support from same-level students. • Peer grouping to practice paraphrasing in PPT. • Provide copy of PPT if student struggles to take notes

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	6. As groups start to finish up their investigation, put the conclusion sentence starters slide on the board and review what they are to do: Summarize what you noticed about what happened when you allowed the marble to roll down the track. Possible sentence starters: *"In this lab, I noticed that…"* *"When we changed the ________, then ________ happened. I think this was because…"* 7. As time permits, have students share out their conclusions. Students should minimally come to the conclusion that the marble never goes as high on the rebound. Extension…why? (marble only has so much energy, friction/air resistance cause the marble to lose some energy) **<u>Day 3 – Energy</u>** 1. Have students turn to SR 2.3 Line Paper to write their notes on today. If students have been taught Cornell Notes, they can easily be incorporated into this portion of the lesson. **NOTE**: Students should NOT copy the entire PPT. To help them learn to sift through information-dense presentations, essential information is in bright green. BUT students should NOT copy word for word. Instead, they read it once, listen to their teacher explain it, and then write it in their own words. Teacher may model this skill the first time and check that students understand how to paraphrase and its purpose. Students may need to ask a partner for assistance or a little extra time as they work on this skill. **ADVANCE**: If your class is ready, put the PPT in all black and have students them identify essential information and paraphrase as they take notes. 2. Use TR 2.3 Energy interactive ppt to guide lesson. Have students read the essential question for the day. After recording the definition of energy, explain that students will be reading some short passages (SR 2.4 PE and KE) with a partner using clarifying bookmarks. Since this is probably students' first time using clarifying bookmarks, have them look at SR 2.4 Clarifying Bookmarks and go over the ppt slide with them. **NOTE**: Have them practice the conversation as a whole class with the definition of Energy before moving on.	**Accelerated Learners:** • May want to add more complicated quantitative data collection during their investigation • Extend investigation to loops • Peer grouping to support student collaboration and critical thinking • PPT in all black

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	Student directions contained in the ppt – expose directions one step at a time: • Step 1: By yourself, silently read the energy. • Step 2: Partner A will read aloud to Partner B descriptions of potential energy and kinetic about potential energy. Partner B will summarize what potential energy is in their own words using the clarifying bookmarks (SR 2.4). • Step 3: Partner B will read aloud to Partner A about kinetic energy. Partner A will summarize what kinetic energy is in their own words using the clarifying bookmarks. • Step 4: Write down a one-sentence definition of each word. Be prepared to share your definitions. 3. Once students have read together and have an idea of what kinetic and potential energy are, they will read the formal definitions from the PowerPoint and work to paraphrase the text and write it their own words. NOTE: this may be difficult for students. If/when they get stuck, refer them to the clarifying bookmarks to help them understand where they are confused about. 4. At the 5 Fingers slide, ask the questions and have the students hold up their fingers for where they think the ball is with the amount of energy asked about (slide is animated – answers will fly in and out)…make sure all students are responding. Explanations: • Greatest PE at 1 because the ball is at its highest point. • Greatest KE at 3 because that is where the ball is moving the fastest. • Least PE at 3 because the ball it at its lowest point. • Least KE at both 1 and 5 because the ball is momentarily not moving at all. 5. Open the link to "How Stuff Works: Roller Coasters." Click through the animation all the way 1 time without explaining. Now tell the students to watch the PE and KE bar graphs and where the roller coaster train is. Click through the animation again, this time slower.	

		6. Display the question, "What is the relationship between PE and KE?" Tell the students to turn to their elbow partners and explain to them what the relationship is. You can show the animation again, if the students need it. 7. Ask students to share and create a bridge map on the board to show the relationship students come up with.  8. Students read the definition of conservation of energy and paraphrase to their partner, then write their version down. 9. Show the video clip "The Physics of Motion – Roller Coasters: The Stop Height Principle." This video is provided in the Electronic Resources. Finish off with note on energy conversion. 10. Show the summary video. This video will open in a web browser when clicked.	
Lesson Reflection			
Teacher Reflection Evidenced by Student Learning/ Outcomes			

Investigating Energy

Day 2

Think and Reflect

Take a look at your Thinking Map from yesterday.

* How do you think the roller coasters have been powered across the centuries?
* Take 10 seconds and elaborate or clarify to your partner how you think roller coasters are powered.
* Share out as a class

Let's Take a Look at a Modern Roller Coaster

Top Ten Steel Roller Coasters in the World

Question Focus

Roller Coasters work by converting potential energy into kinetic energy.

* Working with your team, generate as many questions as you can that correspond with the question focus.
* Do not stop to answer any of the questions.
* Do not judge any of the questions.

Energy Exploration

* Your team is now going to receive materials to investigate different types of energy.
* You will receive:
  foam tubing, a marble, a stopwatch and a meter stick
* Your objective is to come up with 4 different ways that you can have the marble roll down the tubing.

Energy Exploration

Guidelines:

* The marble cannot leave the foam track in order for the trial to be recorded.
* You must collect some type of quantitative data (numbers) for the trial to be recorded.
* The foam track cannot be moved while the marble is moving.
* You must release the marble only, not push it.

Conclusion

* Summarize what you noticed about what happened when you allowed the marble to roll down the tubing.
* Possible sentence starters:
  * "In this lab, I noticed that…"
  * "When we changed the ___________, then ________ happened. I think this was because…"
* Be prepared to elaborate on your idea and share out with the class.

Video Clip first person views (Top Ten Steel Roller Coaster in the World)

Name ___________________________________

Question Generator

Instructions: As a team generate as many questions as you can that relate to the following statement:

Roller Coasters work by converting Potential Energy into Kinetic Energy

Name ___________________________________

Energy Exploration

Materials:

- 3 foot section of foam tubing
- marble
- stopwatch
- meter stick

Guidelines:

1. The marble cannot leave the foam track in order for the trial to be recorded.
2. You must collect some type of quantitative data (numbers) for the trial to be recorded.
3. The foam track cannot be moved while the marble is moving.
4. You must release the marble only, not push it.

Data Table

	Design 1	Design 2	Design 3	Design 4
Diagram				
Observations				

Conclusion:

Energy

Day 3

Essential Question

How is a roller coaster able to travel up hills and do loops without an engine?

Energy

∗Energy – The ability to do work and move an object. Measured in Joules.

Your body takes in energy as food and uses it to make your heart beat, muscles move, etc.

How to Use Clarifying Bookmarks

Clarifiying Bookmarks are a tool to help you decide how to word a sentence depending on what you are trying to do!

What I can do	What I can say
I am going to think about what the selected text may mean.	I'm not sure what this is about, but I think it may mean…
	This part is tricky, but I think it means…
	After rereading this part, I think it may mean…
I am going to summarize my understanding so far.	What I understand about this reading so far is…
	I can summarize this part by saying…
	The main points of this section are…

Types of Energy

∗ Step 1: By yourself, silently read the descriptions of potential energy and kinetic energy.

∗ Step 2: "A" read aloud to "B" about potential energy. "B" summarize what potential energy is in your own words using the clarifying bookmarks.

∗ Step 3: "B" read aloud to "A" about kinetic energy. "A" summarize what kinetic energy is in your own words using the clarifying bookmarks.

∗ Step 4: Write a one-sentence definition of each word. Be prepared to share your definitions.

∗ If you have time, come up with an example situation for each type.

Types of Enegy

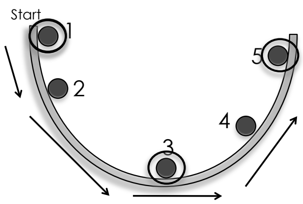
∗Potential Energy – energy stored in an object due to gravity (or an electric or magnetic field).
  ∗Example: A bike at the top of a hill

∗Kinetic Energy – Energy of motion, carried by a moving object.
  ∗Example: A bike rolling down a hill.

5 Fingers

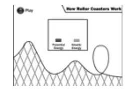
A ball rolls down a U-shaped ramp.

1. At which number is the <u>potential energy</u> the *greatest*?
2. At which number is the <u>kinetic energy</u> the *greatest*?
3. At which number is the <u>potential energy</u> the *least*?
4. At which number is the <u>kinetic energy</u> the *least*?



How Roller Coasters Work

* <u>Animation - How Stuff Works: Roller Coasters</u>



Let's watch the animation again.

This time, look at what happens to the size of the Potential Energy and Kinetic Energy bar graphs.

After the video:

What is the relationship between the potential and kinetic energies?

In other words, when there is a lot of potential energy, what does the kinetic energy look like?

Conserving Energy

* <u>Conservation of energy</u> – the total energy in a system must remain the same. Energy cannot be created or destroyed.
  * Video clip: "The Physics of Motion – Roller Coasters: The Stop Height Principle

* Energy can be changed from potential to kinetic and back again, or to another form of energy like heat.

Summary Video

* <u>External Link</u> will open in your web browser when clicked.

Name ___________________________________

Name ___________________________________

Stop Height Principle Video

Name ___________________________________

Kinetic and Potential Energy

Potential Energy

Potential energy is the same as stored energy. The "stored" energy is held within the gravitational field. When you lift a heavy object you exert energy that later will become kinetic energy when the object is dropped. A lift motor from a roller coaster exerts potential energy when lifting the train to the top of the hill. The higher the train is lifted by the motor the more potential energy is produced, thus forming a greater amount of kinetic energy when the train is dropped. At the top of the hill the train has a huge amount of potential energy, but it has very little kinetic energy.

Kinetic Energy

The word "kinetic" is derived from the Greek word meaning to move, and the word "energy" is the ability to move. Thus, "kinetic energy" is the energy of motion -- it's the ability to do work. The faster the body moves the more kinetic energy is produced. The greater the mass and speed of an object, the more kinetic energy there will be. As the train accelerates down the hill the potential energy is converted into kinetic energy. There is very little potential energy at the bottom of the hill, but there is a great amount of kinetic energy.

From: http://library.thinkquest.org/2745/data/ke.htm

Name ___________________________________

Clarifying Bookmark 1: Talk About what you understand

What I can do	What I can say	What my partner can say
Think About Meaning	After rereading this part, I think it may mean... I'm not sure what this is about, but I think it means...	*I agree/disagree because...* *I think I can help, this part means...*
Get the Gist/Summarize	What I understand about this so far is… The main points of this section are... I can paraphrase this part in these words...	*I agree/disagree because...* *I agree disagree and I would like to add...* *I don't understand, can you explain more?*

SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Day: 4-5** **Lesson: 3**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 2 class periods** **Date:**
Big Idea: Energy plays an important role in manufacturing design. **Essential Question:** What forces create a roller coaster ride?		
Common Core and Next Generation Science Standards	**NGSS: Performance Expectations** **MS-PS2-2.** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. **NGSS: Disciplinary Core Ideas** **PS2.A: Forces and Motion** •For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). •The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. **PS2.B: Types of Interactions** •Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. **PS3.C: Relationship Between Energy and Forces** •When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **Reading Standards for Literacy in Science and Technical Subjects**: RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks **Writing Standards for Literacy in Science and Technical Subjects**: WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research **Speaking and Listening Standards (ELA):** SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in	

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Materials/ Resources/ Lesson Preparation	**Day 4** TR 3.1 Thrilling Forces on RC interactive ppt SR 3.1 What Makes RC So Thrilling? SR 3.2a Article: Batman The Ride SR 3.2b Article: GhostRider SR 3.2c Article: Phantom's Revenge SR 3.2d Article: X2 SR 3.3 Jigsaw Matrix – Roller Coaster Thrills **Day 5** (Teacher/School provides) Cups or beakers (1 per pair/group) Pennies (20-ish per pair/group) Index cards (1 per pair/group) Bucket with handle Water	
Objectives	**Content:** Students will be able to describe the forces that are felt on roller coaster rides: acceleration, g-force, gravity, and centripetal force. Students will investigate inertia and be able to explain the role it plays on a roller coaster ride.	**Language:** Students will read complex text using a jigsaw protocol and "read with a pencil" strategy, listen and respond to other students, and predict outcomes.
Depth of Knowledge Level	☐ **Level 1: Recall** ☒ **Level 2: Skill/Concept** ☒ **Level 3: Strategic Thinking** ☐ **Level 4: Extended Thinking**	
College and Career Ready Skills	☒ **Demonstrating independence** ☒ **Building strong content knowledge** ☒ **Responding to varying demands of audience, task, purpose, and discipline** ☐ **Comprehending as well as critiquing** ☒ **Valuing evidence** ☐ **Using technology and digital media strategically and capably** ☐ **Coming to understand other perspectives and cultures**	

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acceleration
g-force
centripetal force</td><td>air time
weightlessness
balanced and unbalanced force</td></tr>
<tr><td>STUDENTS FIGURE OUT THE MEANING</td><td>gravity</td><td></td></tr>
<tr><td colspan="2">Pre-teaching Considerations</td><td colspan="2">Before the unit
The interactive PPTs will guide teacher and students through entire lesson each day– be sure to preview and familiarize yourself with the flow of each lesson
Jigsaw Activity will require Base Groups and Expert Groups – read lesson continuum for detailed instructions on setting up groups and plan accordingly
Gather lab materials for each pair/group – cup or beaker, ~20 pennies, index card
You will also need one bucket and water for demo.</td></tr>
<tr><td colspan="4">Lesson Delivery</td></tr>
<tr><td colspan="2">Instructional Methods</td><td colspan="2">Check method(s) used in the lesson:
☒ Modeling ☐ Guided Practice ☒ Collaboration
☐ Independent Practice ☒ Guided Inquiry ☒ Reflection</td></tr>
<tr><td>Lesson Continuum</td><td>Lesson Opening</td><td colspan="2"><u>Day 4 – Thrilling Forces on Roller Coasters</u>
Preparing the Learner
Prior Knowledge, Context, and Motivation:
Ask students to open to SR 3.1 in their student books and to take 1 minute to brainstorm the most thrilling aspects of a roller coaster.
Have students use the following sentence frame to share out at their table:
“I think that _______ is the most thrilling part of a roller coaster, because…”
Encourage students to add additional thrill components if they wish.
Have 2-3 students share out for the table to the class using the following sentence starters if needed:
“Matt and Amy think that the most thrilling part of the roller</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td rowspan="2">Activities
Tasks
Strategies
Technology
Questioning
Engagement
Writing
Checking
For
Under-
standing</td><td colspan="2">coaster is _____, because...”
“I think that the best part is ______ because….”
4. Give them an additional 2 minutes to illustrate the most thrilling part of a coaster.</td></tr>
<tr><td><u>Day 4 – Thrilling Forces</u>
Interacting with the concept/text:

Jigsaw Activity on Roller Coasters
1. The students should already be seated in their Base Groups (their regular groups of 4).
**Note: Have 4 stations (these are the Expert Groups) setup throughout the classroom in places that will maximize the distance between the 4 groups. The stations are as follows:
Station A – Batman (~1150 Lexile)
Station B – GhostRider (~1161 Lexile)
Station C – Phantoms Revenge (~1258 Lexile)
Station D – X2 (~1258 Lexile)
2. The teacher will assign each student a letter that corresponds to the expert group station they will be going to (A, B, C, or D). Without telling students, take each child’s individual reading ability into consideration and assign stations accordingly. All articles are already in the student handbooks (SR 3.2).
3. The teacher will send students to their assigned station (Expert Group). There should be 8-10 students per station in a class of 32-40 students.
First Read (in Expert Groups):
4. When the students are settled, the teacher will tell the students they will be reading their article silently on their own for 6 minutes. The teacher will remind them that the goal is not necessarily to finish in the allotted time, but to understand what they do read. If they finish before time is called, the students should reread their article. The Teacher will focus the students’ attention on looking for:
-the most thrilling aspects of the ride
-the different types of forces in action
The teacher will note the time and instruct students to begin reading. The teacher will call out how many minutes remain at the end of each minute.
5. At the end, the teacher will remind students that it is acceptable if they did not finish. They will have other chances to finish reading the article.</td><td>Students Who Need More Support:
• Different reading levels by lexile
• Partnered reading for immediate support
• Collaboration to paraphrase definitions.
• Teacher proximity for immediate feedback support

Accelerated Learners:
• Read more difficult lexile level article
• Take leadership role in Expert and/or Base Group
• Collaboration to paraphrase definitions
• Peer grouping to match ability and skill level.</td></tr>
</table>

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Second Read (in Expert Groups):** 6. When students finish their first read, the teacher will have students look at the Roller Coaster Jigsaw Matrix in their student workbook (SR 3.3). Tell students that they will NOT be writing in the matrix yet, they are just using it to guide their reading. 7. Each student with their expert group, will reread their article with a pencil in hand, underlining or circling information in the article that will help answer the questions on the matrix (students are still NOT writing on the matrix) 8. At the conclusion of the second read, students should then discuss their group answers within their Expert Groups. Once they come to consensus on the best answer they will then write the information on their own matrix. 9. Be sure to give the Expert Groups time to rehearse what they will say when they report back to their Base Groups. Tell students that they are required to use key science terms and academic language when sharing the information with their Base Group. **Return to Base Groups:** 10. With at least 20 minutes remaining, direct students to go back to their "Base Groups." The teacher should assign a random student to begin in each base group. This will ensure that the students don't listen to what groups near them are saying and change their own responses. That first expert student will orally share which article they read and explain the information to fill in that section of the Jigsaw Matrix. As the first expert is sharing his/her information, the other members of the base group will take notes on their matrix and ask clarifying questions. **NOTE:** Students should not copy from the other students' charts. It is important that they *tell (paraphrase)* the other students the information so they have the opportunity to practice the academic language. Then let each of the other students explain their articles. Teacher needs to keep a watch on time – making sure every student has time to speak. **Lesson Closure:** Ask the students to vote on the most thrilling ride they read or heard about. Ask for students to give examples from the text on what makes it so thrilling. Then give them an opportunity to see the ride X2 on the video.	

Lesson Continuum	Activities/Tasks/ Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	<u>**Day 5 – Forces on a Roller Coaster**</u> **NOTE**: Be sure to follow Power Point slides/discussion questions. **Inertia Investigation** 1. Pass out 1 cup, 1 index card and about 20 pennies to each group. This can be done as groups of 4, but probably works better with groups of 2. 2. Tell students to place the card on top of the cup and 1 penny on the card. The students are to remove the card and have the penny fall into the cup. After they get 1 penny, they stack another on top of it. The challenge is to see how many pennies they can get to all fall into the cup. A typical amount is a stack of about 30 pennies. **Stay in the Loop Demonstration** 3. Fill a bucket ¼ to ½ with water. Tell the students that you are going to swing the bucket over your head in a large circle. Ask them to predict whether the water will fall out of the bucket and why or why not. 4. The reason that the water does not come out of the bucket is that you are applying a centripetal force that pulls the bucket in a circle. The water's inertia makes it want to keep moving in the direction that it has been, which is towards the bottom of the bucket. So the water "sticks" to the bottom of the bucket. **Acceleration** 5. Students read the definition of acceleration and create a paraphrase the definition with their neighbor. Check for understanding to make sure their definition is correct. 6. Have the students raise hands for the true/false statements. (The answer to each statement is true because in each the bike is speeding up, slowing down, or changing direction.)	

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Forces** 7. Introduce forces and explain how balanced forces cause no change in motion, while unbalanced forces do cause a change in motion. 8. Explain that while in a loop, a roller coaster experiences a centripetal force that pushes it into a circle. The train's inertia keeps the riders pressed into their seats. Students experience this all the time while riding in a car that is turning. They may have played the "Jello" game with others in the back seat as inertia wants their body to continue in a straight line while the car turns. **G-Force** 9. Ask students if they know what G-force is. Have them share for a moment with their elbow partner. 10. Explain how there can be a negative and positive G-force and what the difference is. 11. Before showing the video "What is G-Force?" have the students think about where the riders are experiencing negative and positive G-forces. Available in the Electronic Resources. **Air Time** 12. After going over the information on Air Time, explain that it is one of the components that makes a roller coaster thrilling. **Lesson Closure** 13. Have students discuss the essential question "What forces create the thrill of a roller coaster ride?" with their elbow partner. Randomly call on students to stand and, in complete sentences, share their answer with the class. If a student does not/cannot answer, say "I'll come back to you," and call on 2 or 3 more students to share. Be sure to come back to the student and have him/her now answer the question.	

Lesson Reflection	
Teacher Reflection Evidenced by Student Learning/ Outcomes	

Thrilling Forces on a Roller Coaster

Day 4

Warm Up SR 3.1

- Think about all of the roller coasters you have ever seen or ridden on.
- What forces create a roller coaster ride?
- **Brainstorm** as many thrilling components as you can think of and write them in the box.
- Draw a picture or diagram that shows the most thrilling part of the ride.

Roller Coaster Jigsaw Expert Groups

A. Batman
B. Ghost Rider
C. Phantoms Revenge
D. X2

Jigsaw Matrix

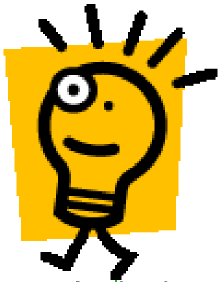
Jigsaw Matrix – Roller Coaster Thrills

	Batman	Ghost Rider	Phantom	X2
Where is the roller coaster found?				
Describe the type of roller coaster.				
What is the maximum speed of the roller coaster?				
Describe the thrilling components of the ride.				
What forces are found in a roller coaster?				

X2 Video

- Here is a video showing the X2 in action.

Name ___________________________________



What Makes Roller Coasters So Thrilling?

In the box below, **brainstorm** as many thrilling components as you can think of.

Draw a picture or diagram that illustrates the most thrilling part of the ride.

Name ___________________________________

BATMAN THE RIDE
Six Flags Magic Mountain

1. Prepare for the ride of your life...hang on tight, but most importantly keep your feet inside the car...but...what happened to the floor of the car? Batman The Ride takes the concept of a roller coaster to a new dimension. On Batman, your feet dangle free from the ski lift style trains that hang from the track overhead.

Batman The Ride – The Story

2. After entering through the Gotham City portal, visitors stroll through Bruce Wayne's beautifully landscaped Gotham City Park, complete with ornate sculptures and an ongoing concert of nature sounds symphony.

3. As unsuspecting guests venture further, the peacefulness of Gotham City Park is suddenly disturbed by unsettling noise in the streets, which are now ruled by Batman's arch-enemies. Guests will encounter a crashed police car, broken fire hydrant and other evidence of the growing chaos in the streets.

4. Once in the underground tunnels beneath Gotham City, guests will finally escape through the Batcave and be whisked away on Batman's newest crime-fighting device, Batman The Ride.

Batman The Ride

5. Suspended from the track, riders fly through the air, feet dangling free, experiencing sensations only felt on an inverted coaster.

6. After cresting the ten story lift hill, the ride begins with a 87-foot twisting dive into a seven story tall vertical loop, followed by a zero-G one-of-a-kind spin and a second 68-foot vertical loop.

Name ___________________________________

7. Riders then proceed at full throttle through several twisting turns, a few quick dips and two more corkscrew inversions sending your feet for the sky, before the brake run.

8. The sensation created by an inverted coaster is very different from that of traditional roller coasters. It is a sensation that every coaster fan must experience. Batman The Ride boasts a top speed of 50 mph that is consistently maintained throughout the ride while giving riders the force of up to 4 G's. The heart pounding centripetal force is felt as riders race around the turns and through the loops.

9. Batman The Ride was built and designed by premier coaster experts Bolliger and Mabillard and was the first inverted roller coaster in Southern California. Today Batman remains one of the most popular attractions at Six Flags Magic Mountain.

Adapted by SAUSD from:

http://www.ultimaterollercoaster.com/coasters/reviews/batman/

Name ___________________________________

GHOSTRIDER

Knott's Berry Farm

1. In 1998 Knott's Berry Farm in Buena Park California set out to build one of world's greatest thrill rides and the first major new attraction in nearly a decade. GhostRider would become one of the tallest, fastest and longest wooden roller coasters in the world.

GhostRider – The Ride Experience

2. Designed to fit into the rugged Western town, GhostRider was the first major attraction for the Ghost Town since the Timber Mountain Log Ride opened in 1969. This state-of-the-art wooden roller coaster instantly became the park's flagship attraction and one of the most visible, seen passing over Grand Avenue at the park entrance and from nearby Beach Boulevard.

3. Seated two to a row, 28-passengers depart the station dipping into a spiral turn before approaching the lift hill. While a nice start, it's just a quick teaser of what's to come.

4. While climbing the lift hill riders are treated to a beautiful Southern California view of Knott's and the nearby surroundings. Don't let the pleasant view fool you because the fun quickly begins at the lift's peak, when without warning, the lead car suddenly disappears over the edge. Falling down the 118 ft in the first drop at a 51-degree angle, to reach a top speed of 56 mph! If you're in the rear prepare for the first of what will be many doses of “airtime.”

Name ___________________________________

5. If you're into airtime then GhostRider is going to be your best friend. GhostRider sets a precedent for what airtime should be on a world-class wooden roller coaster...*EXTREME!*

6. Out of the second drop the lead car powers up a hill and dips into a 180-degree turn with a swooping dip at the edge of Beach Boulevard. The trains take the turn with relentless speed, the centripetal force delivers powerful lateral G forces of up to 3.14 G. Out of the turn, the train dives into the third drop, speeding back towards the station.

7. Slowing down high above the station, the trains make a 180-degree turn without banking on level track, producing an intense amount of lateral G force. But don't be fooled by the milder attitude...a surprise awaits, especially for those in the rear of the train.

8. As unexpected as it comes, the train passes through the block break to suddenly fall with force down a steep drop into the middle of the wooden structure. Those in the rear cars will surprisingly be ejected from their seats with force for some standing airtime from the negative G force.

9. The second half of GhostRider takes on a different feel as it winds its way through the immense wooden structure. Screams can be heard from within as the train flies over Grand Avenue to enter the lower level of the second 180-degree turn at the Beach Boulevard end.

10. Headed back towards the station, the train screams up and over a bunny hill crossing Grand Avenue again with a pop of floating air. Entering the finale the intensity does not let up. The train flies into a helix with a speed of 56 miles per hour. Your body is immediately taken over by lateral G forces that are so intense that even the strongest of souls must beg for forgiveness.

11. With speed to spare, the train rounds the final corner to meet the final break run which quickly slows the mining cars to a stop. The initial reaction...words cannot describe it. Quite simply said, GhostRider's one incredible ride!

Adapted by SAUSD from:
http://www.ultimaterollercoaster.com/coasters/reviews/ghostrider/

Name ___________________________________

PHANTOM'S REVENGE
Kennywood

1. Thrill seekers beware... a Phantom seeking revenge is lurking at Kennywood Park. Will the Phantom get his revenge?

2. Kennywood is a traditional amusement park with a rich history dating back more than a hundred years. Walking through the Pittsburgh, Pennsylvania park is like taking a step back in time. Many of the park's primary attractions date back to the early 1900's and deliver thrills typical of the era.

3. This reinvented roller coaster is nothing typical of a ride you'd find in a traditional amusement park. Instead, it's a ride of gargantuan size, bird's flight airtime and stealth like speed.

4. The first part of the Phantom's Revenge rises up out of the station sixteen stories. The original steel track bends to the right as it forms the first drop that then leads to the first hill. Once you crest the first hill, the anticipation is over as the train begins the impressive and equally famous 228-foot drop. Heading downward your heart starts racing as the train accelerates to 82 mph before diving under the wooden structure for the Thunderbolt roller coaster. With a high-speed turn to the left, the centripetal force creates powerful positive-Gs as you turn high above the ground.

5. Traveling back towards the impressive drop on a curvy descent out of the previous turn, the track travels again under the historic Thunderbolt roller coaster passing this time through a tunnel. Beware of a head chopper or two that might scare even the most seasoned rider. Flying out of the tunnel, the track turns

Name ___________________________________

to the right, where roller coaster fans get a glimpse of the numerous, “air time” producing bunny hills ahead.

6. Two small bunny hops near the Phantom's station and the track dives into an exciting double down, reminiscent of a ride on a bucking bronco. The ejector air caused by the negative G-forces will just about satisfy anyone who craves an adrenaline rush.

7. But beware of the Phantom, for he hasn't finished his revenge and has saved one more hidden surprise. Turning to the right the Phantom's hidden element sends you flying out of your seat as the Phantom pummels you with a double up just before the brake run.

8. The Phantom's trains hit the brake run with impressive force and speed. If there's one criticism about this near perfect ride, it's that it is too short. Only 1 minute and 57 seconds. Why end the party by burning the speed with brakes when another thousand feet of track could've done the same? Of course, you can have too much of a good thing and with the desire for more, you'll just have to hop back in line for a second ride.

9. The final verdict is the new Phantom is a flat out winner, and it's the kind of revenge we love.

Adapted by SAUSD from:
http://www.ultimaterollercoaster.com/coasters/reviews/phantoms-revenge

Name ___________________________________

X2: Six Flags Magic Mountain

1. It's been dubbed the "most anticipated new ride of the decade" and the world's first "4 D Coaster", but until now no one knew for sure. Now the question is did X2 live up to all the hype?

2. X2 is far different compared to the traditional roller coaster. For the first time ever riders are seated in prototype vehicles that spin independently 360-degrees forwards and backwards on a separate axis. The added spinning effect creates an unprecedented and never before "don't know what to expect next" sensation.

3. The quest for amusement parks to build something bigger and better has been at its height in the past several years. But building restrictions are preventing many parks from going taller and faster, so the industry is looking to the designers to come up with new ideas. X2 is exactly that, a new idea that really pushes the roller coaster to a new level.

4. So would X2 live up to the expectations of being the first 4th Dimension Coaster?

5. The first thing riders will notice about X2 are the monster-sized trains inside the station. The 20-foot wide, 70-foot long wing shaped vehicle seats 28 passengers, two abreast in fourteen individual cars, seven positioned on each side of the train.

6. The state-of-the art restraint system adjusts to each rider's size and safely secures the individual for the duration of the ride.

7. Leaving the station facing backwards, the train rounds a turn and begins its ascent up 190 feet, before reaching the crest of the lift hill. Traveling backwards riders get an impressive, sweeping view of Six Flags Magic Mountain, and are not afforded the comfort of seeing what's to come.

8. Before plunging off the near vertical first drop, the seats you're strapped in suddenly flip forward placing the rider in a position few will be comfortable with. Chills run up your spine, as you realize there is nothing between you and the ground below, as you hang in the restraint disoriented by this sudden surprise. Try not to loose focus now, as the train is about to fall off a steel cliff and drop like a brick.

9. The first drop is insane, descending 215 feet at a near vertical 88.5-degree angle, to reach a blazing speed of 76 mph. But get this, just as you reach full velocity, your seat completes that forward flip that you began 200 feet above all while you experience a G-force of up to 4.0.

Name ___________________________________

10. Before you've got any clue about what just happened you're back in the upright position, soaring into the first, massive 185-foot Raven Turn. Fly birdie... FLY as the train gains altitude and soars through the turn placing the riders into a flying position. Look down from eighteen stories, spread those arms out and fly... uh, maybe you should scream... SCREAM!

11. Descending out of the Raven Turn the seats rotate backwards as they descend into a valley in the track, but don't relax as the next surprise awaits. As the train rockets into a bunny hop, the seats do a complete zero-G back flip that is filled with beautiful airtime. This makes for a weightless flip that is a perfect floater, graceful and smooth.

12. So now you realize this ride is filled with surprises... and you'd better believe it. The intensity never lets off as the train rounds a sweeping turn high above the station and dives into one of the best elements of the entire ride.

13. Try combining a half-twist, with a forward flip, while traveling at a furious pace and you get one radical maneuver. And as unbelievable as it seems X2 pulls off this feisty element in style, leaving you so disoriented that you literally cannot comprehend the centripetal force that hurls you into the second Raven Turn.

14. And guess what? The ride is not over! With speed to burn, the train soars through the another Raven Turn, this time on the outside of the track and ascends into the final maneuver, a back flip that concludes by sliding into the brake run.

Adapted by SAUSD from:
http://www.ultimaterollercoaster.com/coasters/reviews/x2/

Name ___________________________________

Jigsaw Matrix – Roller Coaster Thrills

	Batman	Ghost Rider	Phantom	X2
Where is the roller coaster found?				
Describe the type of roller coaster.				
What is the maximum speed of the roller coaster?				
Describe the thrilling components of the ride.				
What forces are found in a roller coaster?				

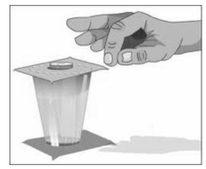
Forces on a Roller Coaster

Day 5

Essential Question: What forces create the thrill of a roller coaster ride?

How Many Pennies?

Penny Magic



Instructions

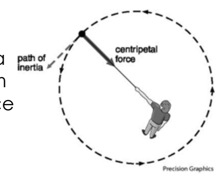
* Start with one penny on the cup. Try to remove the index card and have the penny fall into the cup.
* Once you have mastered one penny, add another penny to see how many pennies you can stack and still get them all into the cup.
* Why don't the pennies fly off the card onto the table?

What happens when you suddenly start or stop moving?

* Inertia – Tendency of an object to resist a change in motion.
  * An object at rest stays at rest
  * An object in motion stays in motion in the same direction unless/until acted upon by an unbalanced force

Stay in the Loop!

* Take a minute to predict:
  Will the water stay inside the bucket? Why or why not?
* YES! As you spin the bucket, the water wants to keep moving in a straight line (inertia) but your arm is exerting centripetal force (force toward the center) – this keeps the water pushing against the bottom of the bucket



Acceleration

* Acceleration – A change in the motion of an object.
* An object will accelerate if it:
  * Speeds up
  * Slows down (called deceleration or negative acceleration)
  * Changes direction

True or False?

1. When you go down a hill on your bike and gain speed, you accelerate. True!
2. When you go 10 miles per hour around a corner, you accelerate. True!
3. When you slow down to stop at a red light, you accelerate. True!

Forces

* Force – a push or pull in any direction. Measured in Newtons (N)
  * If forces are **balanced**, no acceleration occurs.

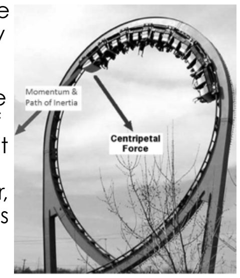
No change in motion.

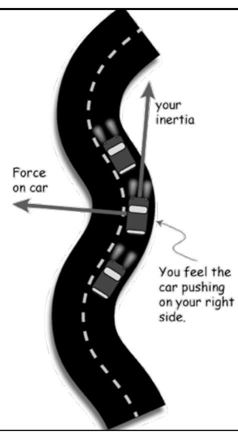
  * If forces are **unbalanced**, the object will speed up, slow down, or change direction.

The object will accelerate to the left.

Acceleration While Changing Direction

* Centripetal force – the force that makes an object follow a curved path like a circle.
* This force points towards the center of the circle (think of the water in the bucket! But instead of the arm exerting the force toward the center, on this roller coaster loop it is the track)





G-Force

* Take a minute to think with your partner: What is G-force? Where have you heard it used before?
* G-force - A force acting on a body as a result of acceleration or gravity
* Right now, you are experiencing 1 G because you are being pulled towards the center of the earth by just gravity.
* If a 100 pound person is experiencing 2 Gs, then it feels like they have a weight of 200 pounds.

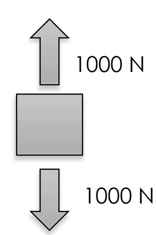
G-Force Video

While the video is playing, think about where the riders are experiencing positive G-force and negative G-force.

Weightlessness

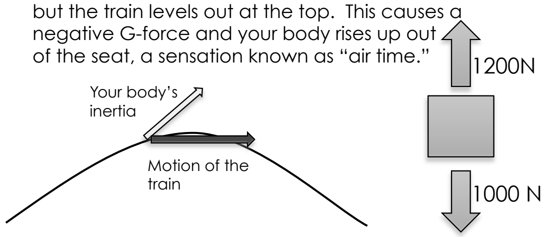
* If the force due to gravity pulling down an object is equal to the force acting upwards on an object, the forces cancel out and the object feels weightless.

Since the gravitational force pulling the object down is equal to the force acting upwards, the object is experiencing zero-Gs.



Air Time

* When the coaster is moving at a high speed and comes to the top of a small hill, the force of gravity pulling downward on your body is less than your body's upward inertia.
* Your body's inertia wants to keep traveling up, but the train levels out at the top. This causes a negative G-force and your body rises up out of the seat, a sensation known as "air time."



Wrap Up

* Pair Share with your elbow partner: "What forces create the thrill of a roller coaster ride?"
* Be prepared to stand and share your answer with the class!

What is a G-Force? Video

Name ___________________________________

Name ____________________________________

SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Day: 6-7** **Lesson: 4**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 2 Class Periods** **Date:**
Big Idea: When designing a roller coaster, engineers must consider many different scientific principles. **Essential Question**: What types of injuries might a person sustain on a roller coaster ride? **Essential Question**: What forces play a role in injuries sustained from roller coaster rides? **Essential Question**: How do roller coaster engineers and park safety managers address the excessive G-forces exerted by roller coasters on its riders? **Essential Question**: Are roller coasters safe or unsafe?		
Common Core and Next Generation Science Standards	**NGSS: Performance Expectations** **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **NGSS: Disciplinary Core Ideas** **PS2.A: Forces and Motion** •For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). •The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. **PS2.B: Types of Interactions** •Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. **PS3.C: Relationship Between Energy and Forces** •When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **Reading Standards for Literacy in Science and Technical Subjects**: RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts	

	Writing Standards for Literacy in Science and Technical Subjects: WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research **Speaking and Listening Standards (ELA):** SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation	
Materials/ Resources/ Lesson Preparation	**Day 6** TR 4.1 Are Roller Coasters Safe? Interactive PPT SR 4.1 Quick Write SR 4.2 Common Injuries Related to RC Riding Matrix **Day 7** TR 4.3 RC Safety Statistics Interactive PPT SR 4.3 Predication Matrix SR 4.4a Article: Amusement Ride Safety Tips SR 4.4b Article: Ride Safety in the US SR 4.4c Article: Design and Technology SR 4.4d Article: G-Forces TR 4.5 Vocabulary Review Jigsaw cards – 1 set per group SR 4.5 Vocabulary Review Jigsaw	
Objectives	**Content:** Students will be able to describe some injuries that can happen on roller coasters and understand that roller coasters are safe to ride for the general population.	**Language:** Students will be able to defend the idea that roller coasters are safe to ride using evidence from text. Students will work collaboratively on vocabulary review jigsaw.
Depth of Knowledge Level	☒ **Level 1: Recall** ☒ **Level 3: Strategic Thinking**	☐ **Level 2: Skill/Concept** ☐ **Level 4: Extended Thinking**
College and Career Ready Skills	☒ **Demonstrating independence** ☐ **Building strong content knowledge** ☒ **Responding to varying demands of audience, task, purpose, and discipline** ☒ **Comprehending as well as critiquing** ☒ **Valuing evidence** ☐ **Using technology and digital media strategically and capably** ☒ **Coming to understand other perspectives and cultures**	

<table>
<tr><td colspan="2">Common Core Instructional Shifts</td><td colspan="2">☒ Building knowledge through content-rich nonfiction texts
☒ Reading and writing grounded from text
☒ Regular practice with complex text and its academic vocabulary</td></tr>
<tr><td rowspan="3">Academic Vocabulary (Tier II & Tier III)</td><td rowspan="2">TEACHER PROVIDES SIMPLE EXPLANATION</td><td>KEY WORDS ESSENTIAL TO UNDERSTANDING</td><td>WORDS WORTH KNOWING</td></tr>
<tr><td>Statistics</td><td></td></tr>
<tr><td>STUDENTS FIGURE OUT THE MEANING</td><td>restraints</td><td>subdural hematoma
whiplash
fracture
aneurysm</td></tr>
<tr><td colspan="2">Pre-teaching Considerations</td><td colspan="2">Before the unit
The interactive PowerPoint will guide teacher and students through the entire lesson each day – be sure to preview and familiarize yourself with the flow of each lesson
Students will be working at times with elbow partners, at other times in groups of 4. Each student will be reading one of four safety articles and teacher needs to consider reading ability of student when assigning articles to specific students</td></tr>
<tr><td colspan="4">Lesson Delivery</td></tr>
<tr><td colspan="2">Instructional Methods</td><td colspan="2">Check method(s) used in the lesson:
☒ Modeling ☐ Guided Practice ☒ Collaboration
☐ Independent Practice ☐Guided Inquiry ☒ Reflection</td></tr>
<tr><td>Lesson Continuum</td><td>Lesson Opening</td><td colspan="2">Preparing the Learner
Prior Knowledge, Context, and Motivation:

<u>Day 6</u>
Quick Write
1. Have students open their handbook to SR 4.1 Quick Write
2. The teacher will begin by telling students to remember a time they have gone to an amusement park or a fair or buckled up for a car trip.
3. Ask Question: What do workers do to keep you safe on a ride? Give students 2 minutes to list as many things as they can think of in the box provided.
4. Ask Question: What does the park do to keep you safe on a ride? Again, give students 2 minutes to list as many things as they can think of.</td></tr>
</table>

		Pair-Share with Elbow Partner 1. Student with the longest hair goes first, and reads their ideas to their partner who will add any ideas they did not already have listed. 2. Students then reverse roles. 3. Teacher must circulate as students are working to ensure that ALL students are speaking and others are actively listening according to the pair-share protocol.

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Interacting with the concept/text:** **<u>Day 6 – Are Roller Coasters Safe?</u>** **Injury Matrix** 1. Have students open handbook to SR 4.2. Have them read the matrix on their own for 3 minutes. 2. Now have students reread the article using the "read with a pencil" strategy – underline, circle, annotate in margins – the information that they find the most interesting 3. From the information, students are to create 3 questions that can be answered citing evidence in the text of the matrix. Have students write these questions in the space at the bottom of the paper. 4. Students will now work with their elbow partner. The partner with the shortest last name gets to go first. First partner asks his three questions of the second partner, who must find the answers in the matrix. 5. Once the first partner's questions have been answered, the roles reverse. 6. The next slide shows clips of recent headlines on roller coaster accidents. (The details have purposely been left out as the ultimate goal of this lesson is to emphasize that roller coaster rides are very safe). At this point, students might be wondering if riding roller coasters is such a good idea. **Opinion Lineup** 7. Ask students, based on the injuries you have read about and the headlines, how likely are you to ride on a roller coaster? Give them a moment to silently decide where they would place themselves on the continuum (from NEVER! to ABSOLUTELY!) 8. Have students talk to the other group members and share what they think (and why!). The group needs to come to consensus about where they would place themselves on the continuum and why. 9. Each group will send one representative up to the class lineup – will need to tell students where Never starts and Absolutely ends. (If you feel your students can handle it, you could have all the students line up.) 10. Randomly ask the students in the lineup to explain why the group chose that position. Ask as many students as time permits!	**Students Who Need Additional Support** • Differentiation through lexile level • Partner work for immediate support • Teacher proximity for immediate support • Individual work allows for self-pacing **Accelerated Learners:** • Differentiation through Lexile level • Opportunities to take on leadership roles • Partnering by ability • Individual work allows for self-pacing • Jigsaw alternative: Generate own clues for vocabulary terms

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding		
		Lesson Closure Let students know that tomorrow they will be seeing the other side of the safety issue. **<u>Day 7 - Roller Coaster Safety Statistics</u>** **Prediction Matrix and Article Readings** 1. Have students open their handbooks to SR 4.3. The prediction matrix allows students to do a quick skim of the article, and then generate background knowledge and questions before they actually read. 2. Assign students articles based on reading ability. • 4.4a Amusement Ride Safety Tips~1237 Lexile • 4.4b Ride Safety in the US ~1420 Lexile • 4.4c Design & Technology~1673 Lexile (short in length) • 4.4d G-Forces ~1525 Lexile (NOTE: Longest article by far with more information) 3. Direct students to skim their article and make predictions/questions about what they think the article is about. Write these in the "my predictions" column on their matrix. 4. Have students share their predictions with their group and write in other students' predictions in the "my group's predictions." Students will see that the articles are related, but cover the safety issue from various angles. 5. Have students now silently read their articles using the "read with a pencil" strategy. 6. When done reading, students are to write a summary sentence that captures the message in their article. They can support this message with details as well. 7. Each student will now share their summary statement with the group – this time D goes first, then C, B, A **Vocabulary Review Jigsaw** **1.** Direct students to SR 4.5 Vocabulary Review Jigsaw. Using a "fishbowl" approach, demonstrate how this works by having 3 students join you at the front of the class. **2.** Using the 4 Vocabulary Review Jigsaw Cards, model how each group member participates by reading their clue. Model how to fill out the Vocabulary Review Jigsaw Worksheet,	

		by displaying it on the document camera. **3.** Work through #1 of the Vocabulary words so that all class members have a clear idea of how this strategy works. **4.** Students should work in groups of 4. The teacher should give each group of 4 a set of the Vocabulary Review Jigsaw cards. To get set up: • Student 1 will be holding Card A • Student 2 will be holding Card B • Student 3 will be holding Card C • Student 4 will be holding Card D **5.** To begin - Student 1 will select a number (1-12). All group members will circle that number on their Vocabulary Review Jigsaw worksheet. Student 1 will read that clue out loud to the group. Each group member will write the clue on their worksheet. This pattern will continue until the group has attempted to correctly identify all 12 vocabulary words. **6.** To conclude - have each group choose one group member's worksheet to be graded (perhaps the person's worksheet with the best printing or handwriting). Direct groups to pass their paper to another group to be graded. **7.** Go over the correct answers with the class, while reading the correct definitions out loud. Collect the graded worksheets to be recorded in the grade book if you wish. ***NOTE: <u>ALTERNATIVE VERSION FOR HIGHER EL LEVEL</u>*** Instead of providing students with the clues for the vocabulary words, have each group create four different clues for the terms. Encourage students to create more genuine clues for each term rather than guiding prompts related to syllables or starting/ending letter. Have groups swap clues with another group and continue with steps #4-7 as listed above.	

Lesson Reflection	
Teacher Reflection Evidenced by Student Learning/ Outcomes	

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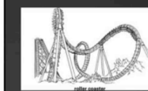
Are Roller Coasters Safe??

Day 6

Quick Write and Partner Discussion

Think of a time you have gone to an amusement park or a fair….

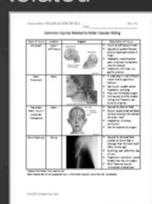


What do <u>workers</u> do to keep you safe on a ride?
List as many things as you can think of on your paper

What does the <u>park</u> do to keep you safe on a ride?
List as many things as you can think of on your paper

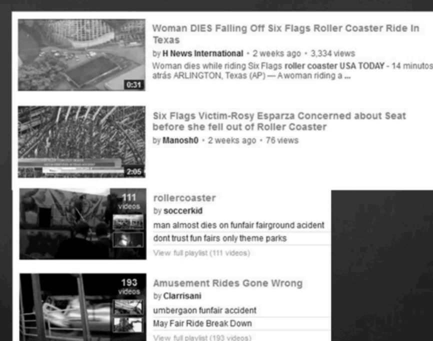
- Working with your partner, determine which of you has the longest thumb.
- The partner with the longest thumb will read their list of ideas out loud.
- The partner with the shortest thumb will add any ideas they did not already have listed.
- Reverse roles.

Matrix of Common Injuries Related to Roller Coaster Riding



- **Read Matrix silently for 3 min**
- **Reread "with a pencil" highlighting what you think is the most interesting information**
- **Create 3 questions based on your reading, writing the questions at the bottom of the page**
- **With your partner, determine who has the shortest last name. This person will begin by asking their partner the questions.**
- **When your partner has successfully answered the 3 questions, reverse roles.**

Recent Headlines



Opinion LineUp

Based on the what you have read about injuries and the recent headlines, think about this question:

How likely are you to ride on a roller coaster?

NEVER!! | Probably Not | Maybe | Probably | ABSOLUTELY!!

Opinion LineUp

NEVER!! | Probably Not | Maybe | Probably | ABSOLUTELY!!

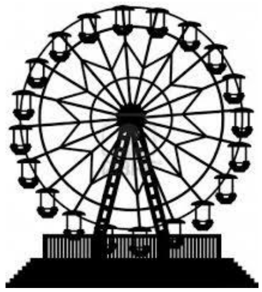
Silently decide where you would place yourself on this opinion lineup

Turn to your group partners and giving everyone a chance to speak, talk about your choices, why you think that way, and COME TO CONSENSUS about where you would place yourselves as a group. You must agree! You will send one representative up to the class lineup and they need to be able to defend your group's position.

Class LineUp

Name ___________________________________

Quick Write



roller coaster

Think of a time you have gone to an amusement park or a fair….

What do <u>workers</u> do to keep you safe on a ride?	What does <u>the park</u> do to keep you safe on a ride?
List as many things as you can think of below:	List as many things as you can think of below:

Working with your partner, determine which of you has the longest hair.

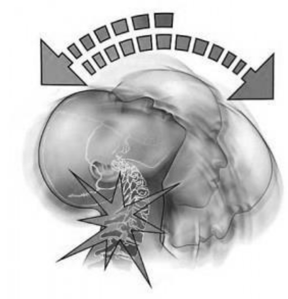
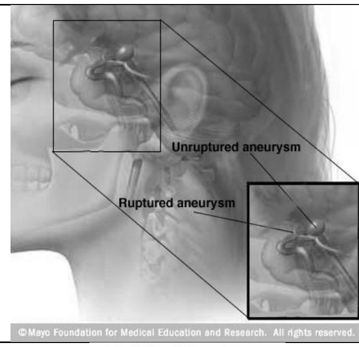
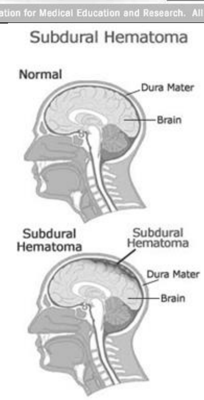
The partner with the longest hair will read their listed ideas out loud.

The partner with the shortest hair will add any ideas they did not already have listed.

Reverse roles.

Name ___________________________________

Common Injuries Related to Roller Coaster Riding Matrix

Type of Injury	Location	Diagram	Description of Injury
Whiplash	Neck – soft tissue	 http://drmartinschmaltz.com/whiplash-injuries/	• Injury to soft tissue in neck • Caused by sudden forward and/or backward motion of head • Headache, neck/shoulder pain, dizziness – symptoms may be delayed • Treatment with heat, ice, gentle exercise
Brain Aneurysm	Brain	 	• A weak area in wall of blood vessel that bulges like a balloon • Can burst - sudden severe headache, vomiting, • Requires immediate surgery • Not caused by roller coaster riding, but if present, can burst during ride
Traumatic Brain Injury – subdural hematoma	Brain	 http://www.health-pictures.com/conditions5/subdural-hematoma.htm#axzz2by3STD2g	• Caused by blow to head • Blood vessels break and blood collects between the skull and the brain itself • Headaches, dizziness, confusion • Can be repaired by surgery
Bone Fractures	Bones		• Caused by physical force exerted on bone that is stronger than the bone itself (falls, twists, etc) • Swelling, pain, deformity, loss of use • Treatment – set bone; severe breaks may require surgery • Skull fractures require immediate medical care

Medical information from webmd.com

Seek medical help for any suspected injury – information above is a summary list, not detailed

Roller Coaster Safety Statistics

Day 7

Roller Coaster Safety Statistics

Student A: Amusement Ride Safety Tips
Student B: Ride Safety in the United States
Student C: Design and Technology
Student D: G-Forces

Skim your article and make predictions/questions about what you think the topic of your article is (left side of Prediction Matrix)
Share your predictions/questions with your group (right side of PM)
Silently reread your article with a pencil, underlining or circling the most important information
Write a sentence that summarizes the overall message in your article
Share out with your group – D first, then C, B, and A
At the bottom of your Prediction Matrix, write down what your partners shared

Now What Do You Think?

Rethink your position on the Opinion Lineup – Would you change your opinion based on what you learned reading the articles?

Vocabulary Review Jigsaw

Before moving on to the Engineering part of our unit, let's review some of the academic vocabulary you have learned over the past 7 days!

Name ___________________________________

Prediction Matrix

My Article ____

My Predictions and Questions	My Group's Predictions and Questions
After Reading – Summarize the overall message of your article	
As you share – What did you learn from your partners?	

- Skim your article and make predictions/questions about what you think the topic of your article is
- Share your predictions/questions with your group
- Silently reread your article with a pencil, underlining or circling the most important information
- Write a sentence that summarizes the overall message in your article
- Share out with your group – D first, then C, B, and A
- Write down what your partners shared

Name ___________________________________

Amusement Ride Safety Tips

International Association of Amusement Parks and Attractions (IAAPA)

Safety is the Amusement Park Industry's Number 1 Priority

Safety is a partnership between an amusement park and its patrons. Unfortunately, a majority of the injuries occur because the guest didn't follow posted ride safety guidelines or rode with a pre-existing medical condition.

IAAPA created a list of amusement ride safety tips for guest use.

- Obey listed age, height, weight, and health restrictions.
- Observe all posted ride safety rules.
- Keep hands, arms, legs and feet inside the ride at all times.
- Remain seated in the ride until it comes to a complete stop and you are instructed to exit.
- Follow all verbal instructions given by ride operators or provided by recorded announcements.
- Always use safety equipment provided and never attempt to wriggle free of or loosen restraints or other safety devices.
- Parents with young children should make sure that their children can understand safe and appropriate ride behavior.
- Never force anyone, especially children, to ride attractions they don't want to ride.
- If you see any unsafe behavior or condition on a ride, report it to a supervisor or manager immediately.

http://www.iaapa.org/safety-and-advocacy/safety/amusement-ride-safety/amusement-ride-safety-tips#sthash.qn8iVCvc.dpuf

Name ___________________________________

Ride Safety in the United States

International Association of Amusement Parks and Attractions (IAAPA)

Safety is the Amusement Park Industry's Number 1 Priority

- Nearly 300 million people visit the approximately 400 amusement parks in the United States annually and take nearly 2 billion safe rides.
- 61 of the 1,415 ride-related injuries reported in 2011, or less than 5 percent of all ride injuries, were considered serious, meaning they required some form of overnight treatment at a hospital.
- The likelihood of being injured seriously enough to require overnight hospitalization for treatment is 1 in 24 million. The chance of being fatally injured is 1 in 750 million. (Based on an average of five rides per guest.)

One of the Safest Forms of Recreation in the United States

Activity: Number of serious injuries per million participant days (based on estimates from the National Sporting Goods Association)

- Roller skating: 912
- Basketball: 799
- Football: 704
- Soccer: 405
- Fishing: 85
- Golf: 53
- Exercising with equipment: Nine
- Playing billiards: Eight
- Camping: Five

Comparatively, data from the National Highway Traffic Safety Administration shows that the number of deaths on America's roadways in 2011 was 32,367.

The National Weather Service estimates the chance of being struck by lightning in the U.S. is 1 in 775,000.

http://www.iaapa.org/safety-and-advocacy/safety/amusement-ride-safety/safety-in-us#sthash.OXdWK94U.dpuf

Name ___________________________________

Design and Technology

International Association of Amusement Parks and Attractions (IAAPA)

Technological Advancements Result in Safer Experiences

- The design and development of amusement rides requires a mastery of physics, engineering, and mathematics.
- As technology has improved to include computers, advanced materials, and certain design innovations, the result has been an increasingly rigorous, complex, and precise creative process.
- This process has contributed to an extraordinary safety record proving amusement rides are one of the safest forms of recreation available to the public.
- The amusement park industry's tradition of continual improvement greatly enhances ride safety. For example, the introduction of force reactive supports, headrests, comfort padding, seat dividers, ratcheted restraints, computer controls, and magnetic braking systems.
- Modern-day ride designers employ a steady stream of advances to create new, unique, and safe amusement rides and attractions.

Amusement ride manufacturers applied the industry's biodynamic knowledge as it relates to G-forces to the design and construction of rides to ensure a safe experience.

While technological gains have led to the development of bigger and faster rides, overall G-force levels have generally remained the same because riders' tolerance levels have not changed.

http://www.iaapa.org/safety-and-advocacy/safety/amusement-ride-safety/design-techology#sthash.AZKqvBgD.dpuf

Name ___________________________________

G-Forces

International Association of Amusement Parks and Attractions (IAAPA)

- Equal the force of gravity
- One G is equal to the normal pull of earth's gravity on the body.
- Modern-day ride designers employ a steady stream of advances to create new, unique, and safe amusement rides and attractions.
- Amusement ride manufacturers applied the industry's biodynamic knowledge (collected over years) as it relates to g-forces to the design and construction of rides to ensure a safe experience.
- While technological gains have led to the development of bigger and faster rides, overall g-force levels have generally remained the same because riders' tolerance levels have not changed.

When discussing the effects of g-forces on a person who is on a ride, the duration of the g-force and a multitude of other variables must be considered. When it comes to the higher–g sections of amusement rides, exposure often lasts fractions of a second. Therefore, the rider does not experience any adverse effects. Blackouts and other health issues associated with Gs require exposure to g-forces which are either greater in magnitude or of much longer duration than those achieved by today's amusement rides.

A study by Murray Allen, MD, Ian Weir-Jones, P. Eng, Ph.D., and several other doctors and engineers was published in the November 1994 edition of Spine. The study "found that in one event of daily activity, the vector acceleration of 10.4 g was experienced uneventfully." Our bodies are exposed to greater gravitational pull during our everyday lives than that of an amusement park ride.

Examples of everyday gravitational forces:

- Sneeze 2.9
- Cough 3.5
- Crowd jostle 3.6
- Slap on back 4.1
- Hop off step 8.1
- Plop down in chair 10.1

At least five independent scientific reviews have analyzed the issue of amusement ride g-forces, and all five have concluded: The rotational accelerations experienced by the head during rides pose no risk of brain injury to the general populace.

http://www.iaapa.org/safety-and-advocacy/safety/amusement-ride-safety/g-forces#sthash.Y29qWhNZ.dpuf

Roller Coaster Physics
Vocabulary Review Jigsaw

Card A

1.	This word starts with the letter	G
2.	This phrase has three words.	
	The first word starts with	C
	The second with the letter	O
	The third with the letter	E
3.	This word starts with the letter	A
4.	This word starts with the letter	F
5.	This phrase has two words.	
	The first word starts with	P
	The second with the letter	E
6.	This word starts with the letter	H
7.	This phrase has two words.	
	The first word starts with	C
	The second with the letter	F
8.	This phrase has two words.	
	The first word starts with	G
	The second with the letter	F
9.	This word starts with the letter	I
10.	This phrase has two words.	
	The first word starts with	A
	The second with the letter	T
11.	This word starts with the letter	W
12.	This phrase has two words.	
	The first word starts with	K
	The second with the letter	E

Roller Coaster Physics
Vocabulary Review Jigsaw

Card B

1. This word has 3 syllables.

2. The first word has 4 syllables.
   The second word has 1 syllable.
   The third word has 3 syllables.

3. This word has 5 syllables.

4. This word has 1 syllable.

5. The first word has 3 syllables.
   The second word has 3 syllables.

6. This word has 4 syllables.

7. The first word has 4 syllables.
   The second word has 1 syllable.

8. The first word has 1 syllable.
   The second word has 1 syllable.

9. This word has 3 syllables.

10. The first word has 1 syllable.
    The second word has 1 syllable.

11. This word has 3 syllables.

12. The first word has 3 syllables.
    The second word has 3 syllables.

Roller Coaster Physics
Vocabulary Review Jigsaw

Card C

1.	The last letter in this word is	y
2.	The last letter in this phrase is	y
3.	The last letter in this word is	n
4.	The last letter in this word is	e
5.	The last letter in this phrase is	y
6.	The last letter in this word is	a
7.	The last letter in this phrase is	e
8.	The last letter in this phrase is	e
9.	The last letter in this word is	a
10.	The last letter in this phrase is	e
11.	The last letter in this word is	s
12.	The last letter in this phrase is	y

Roller Coaster Physics
Vocabulary Review Jigsaw

Card D

1. It is “force of attraction between two objects – what pulls objects towards the earth.”
2. It means “the total energy in a system must remain the same.”
3. It is “the change in motion of an object.”
4. It is “a push or pull in any direction.”
5. It is “stored energy.”
6. It is “collection of blood between the skull and the brain.”
7. It is “the force that allows objects to follow a curved path.”
8. It is “a force acting on a body as a result of acceleration or gravity.”
9. It is “the tendency of any object to resist a change in motion.”
10. It is “what you feel at negative g-force – when you feel like you are rising up out of the roller coaster car.”
11. It is “felt at 0 G”
12. It is “energy of motion”

Roller Coaster Physics
Vocabulary Review Jigsaw

Answer Sheet

1. Gravity
2. Conservation of Energy
3. Acceleration
4. Force
5. Potential Energy
6. Hematoma
7. Centripetal Force
8. G Force
9. Inertia
10. Air Time
11. Weightlessness
12. Kinetic Energy

Name ___________________________________

Vocabulary Review Jigsaw Worksheet

- Work with your partners to complete the Vocabulary Review Jigsaw.
- Your goal is to correctly identify as many of the 12 vocabulary words as possible.
- Your group will receive points for each correct vocabulary word.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

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SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Day: 8** **Lesson: 5**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 1 Class Period** **Date:**
Big Idea: When designing a roller coaster, engineers must consider many different scientific principles. **Essential Question:** What is the engineering design process?		
Common Core and Next Generation Science Standards	**NGSS: Performance Expectations** **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **NGSS: Disciplinary Core Ideas** **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** •A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. •There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. •Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. •Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** •Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. •The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

	Reading Standards for Literacy in Science and Technical Subjects: RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks **Writing Standards for Literacy in Science and Technical Subjects**: WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience **Speaking and Listening Standards (ELA):** SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation	
Materials/ Resources/ Lesson Preparation	TR 5.1 Engineering Design Process interactive PPT Electronic Resource: TED talk: http://marshmallowchallenge.com/Welcome.html Electronic Resource 5.2: Roller Coaster Designer Lab Materials for each group: - 20 sticks of spaghetti - 1 meter of string - 1 meter of masking tape - 1 large marshmallow Lab materials for teacher (teacher/school provides) - 1 measuring tape or meter stick - 1 timer SR 5.1 Marshmallow Challenge Reflection SR 5.2 Engineering Design Process SR5.3 Roller Coaster Challenge Letter	
Objectives	**Content:** Students will understand the engineering design process through a building activity.	**Language:** Students will talk collaboratively to complete the challenge and will write a reflection on how their group worked collaboratively.
Depth of Knowledge Level	☐ **Level 1: Recall** ☒ **Level 3: Strategic Thinking**	☐ **Level 2: Skill/Concept** ☒ **Level 4: Extended Thinking**

College and Career Ready Skills	☐ **Demonstrating independence** ☐ **Building strong content knowledge** ☒ **Responding to varying demands of audience, task, purpose, and discipline** ☐ **Comprehending as well as critiquing** ☐ **Valuing evidence** ☐ **Using technology and digital media strategically and capably** ☒ **Coming to understand other perspectives and cultures**	
Common Core Instructional Shifts	☒ **Building knowledge through content-rich nonfiction texts** ☒ **Reading and writing grounded from text** ☒ **Regular practice with complex text and its academic vocabulary**	
Academic Vocabulary (Tier II & Tier III)	**KEY WORDS ESSENTIAL TO UNDERSTANDING**	**WORDS WORTH KNOWING**
TEACHER PROVIDES SIMPLE EXPLANATION	engineering design process	trials constraints criteria
STUDENTS FIGURE OUT THE MEANING		
Pre-teaching Considerations	**Before the unit** The interactive PPT will guide teacher/students through entire lesson – be sure to preview and familiarize yourself with the flow of the lesson Put the lab materials into trays or boxes ready to be handed out Preload the TED talk video	
Lesson Delivery		
Instructional Methods	**Check method(s) used in the lesson:** ☐ **Modeling** ☐ **Guided Practice** ☒ **Collaboration** ☐ **Independent Practice** ☒ **Guided Inquiry** ☒ **Reflection**	
Lesson Continuum — **Lesson Opening**	**<u>Day 8 – Engineering Design Process</u>** **Preparing the Learner** Prior Knowledge, Context, and Motivation: Tell students, "*Safety is one of many components or constraints placed on engineers when they are designing. In today's lesson, we will be exploring other aspects of the engineering process by creating the tallest tower that you can build that can hold one large marshmallow without breaking.*"	

<table>
<tr>
<td rowspan="1">Lesson Continuum</td>
<td>Activities/Tasks/Strategies/Technology/
Questioning/Engagement/Writing/Checking for Understanding</td>
<td>Interacting with the concept/text:

1. Show the PowerPoint and go over the guidelines. You have 18 minutes to build the tallest <u>freestanding</u> structure that can hold the entire marshmallow. Each group will get:
• 20 sticks of spaghetti
• 1 meter of string
• 1 meter of masking tape
• 1 large marshmallows
Use as much or as little of the materials as you need You can cut or break anything except the marshmallow.
2. While students are building, walk around and call out the progress. For example, “Table 10 has a structure that is 1 foot high already!”
3. When the timer goes off, only measure the structures that are freestanding and have the intact marshmallow on top.
4. Once a winner has been determined, have students turn to their student workbook (SR 5.1) and answer the reflection questions regarding the process they used to build the tower.
5. Have students share out and draw connections to the engineering design process. For example, you may want to ask:
Raise your hand if you created a successful tower.
What was your process?
Did you create prototypes first?
Did you consider your constraints?
How about the unsuccessful towers?
What was your process like?”
6. Make the connection between the marshmallow and the assumptions of the design process. You can ask the students:
How many of you assumed that the marshmallow would be light and fluffy and easy to place on the top of your tower. Was it?
The marshmallow is a metaphor for the assumptions you might have in the process. For example consider what does the real customer need?
The cost of the product?
The time you have to construct?
You will need to work together, create prototypes and redesign throughout the whole process.</td>
<td>Students Who Need Additional Support

• Hands on-inquiry
• Collaboration with peers for immediate feedback
• Teacher proximity for support
• Visual supports

Accelerated Learners:
• Engage students in a writing activity based on the TED talk “Marsh-mallow Challenge”</td>
</tr>
</table>

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	7. Time permitting, show the Marshmallow Challenge TED talk (7 minutes) 8. Have them turn to the Roller Coaster Challenge Letter (SR 5.3) in their student handbook and put the slide on the board. Read the challenge aloud as they follow along with you. 9. The next slide repeats the Engineering Design Process. Explain to the students that every engineer follows a similar process when designing/redesigning products….and they will be following it also! **Lesson Closure:** To tie in today's lesson on the Engineering Design Process with the Challenge Letter they just read, show the video of a Roller Coaster Designer.	

Lesson Reflection	
Teacher Reflection Evidenced by Student Learning/ Outcomes	

Engineering Design Process

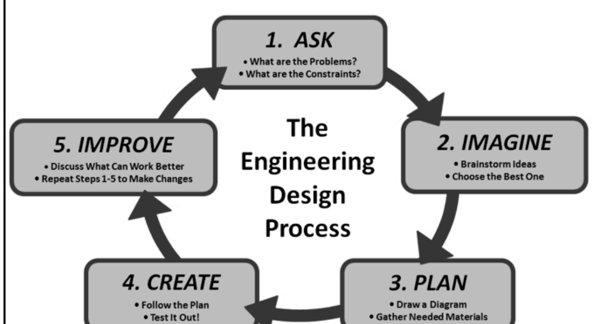
Day 8

Marshmallow Challenge

Marshmallow Challenge

* ***Your mission***: In 18 minutes, build the tallest <u>freestanding</u> structure that can hold the entire marshmallow.
* Each team will receive:
  * 20 sticks of spaghetti
  * 1 meter of string
  * 1 meter of tape
  * 1 marshmallow
* Use as much or as little of the materials as you need
* You can cut or break anything except the marshmallow

Engineering Design Process



The Marshmallow As A Metaphor

* In the engineering process you will need to identify these assumptions in your project:
  * What does the real customer need?
  * The cost of the product?
  * The time you have to construct?

TEST early and often!

All of these components lead to effective innovation!

Roller Coaster Challenge Letter

Turn to SR 5.3

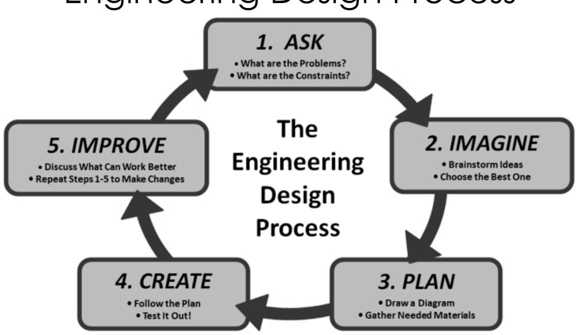

Roller Coaster Challenge Letter

Dear Engineering Design Teams,

The owners of Six Flags Magic Mountain are seeking proposals for a new roller coaster ride. This coaster must thrill riders young and old with unique design features that incorporate the best in safety and engineering while providing an unforgettable experience.

It's no secret that Six Flags Magic Mountain is in desperate need of a new high-interest ride. Since the accident, attendance has dropped dramatically. Our goal is to attract roller coaster fans from near and far and restore their faith in our rides. The future of our local theme park rides on your ingenuity.

Engineering Design Process



Designing a Roller Coaster

Electronic Resource 5.1a Coaster Designer

Name ___________________________________

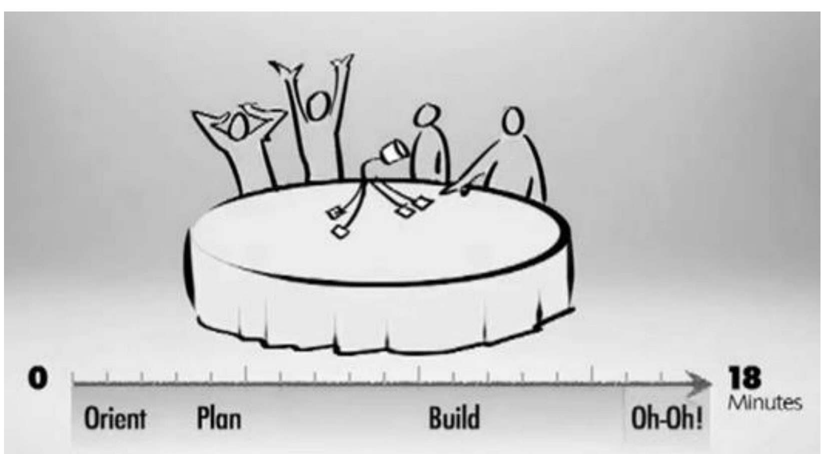
Marshmallow Challenge Reflection

1. Did your team successfully complete the challenge?

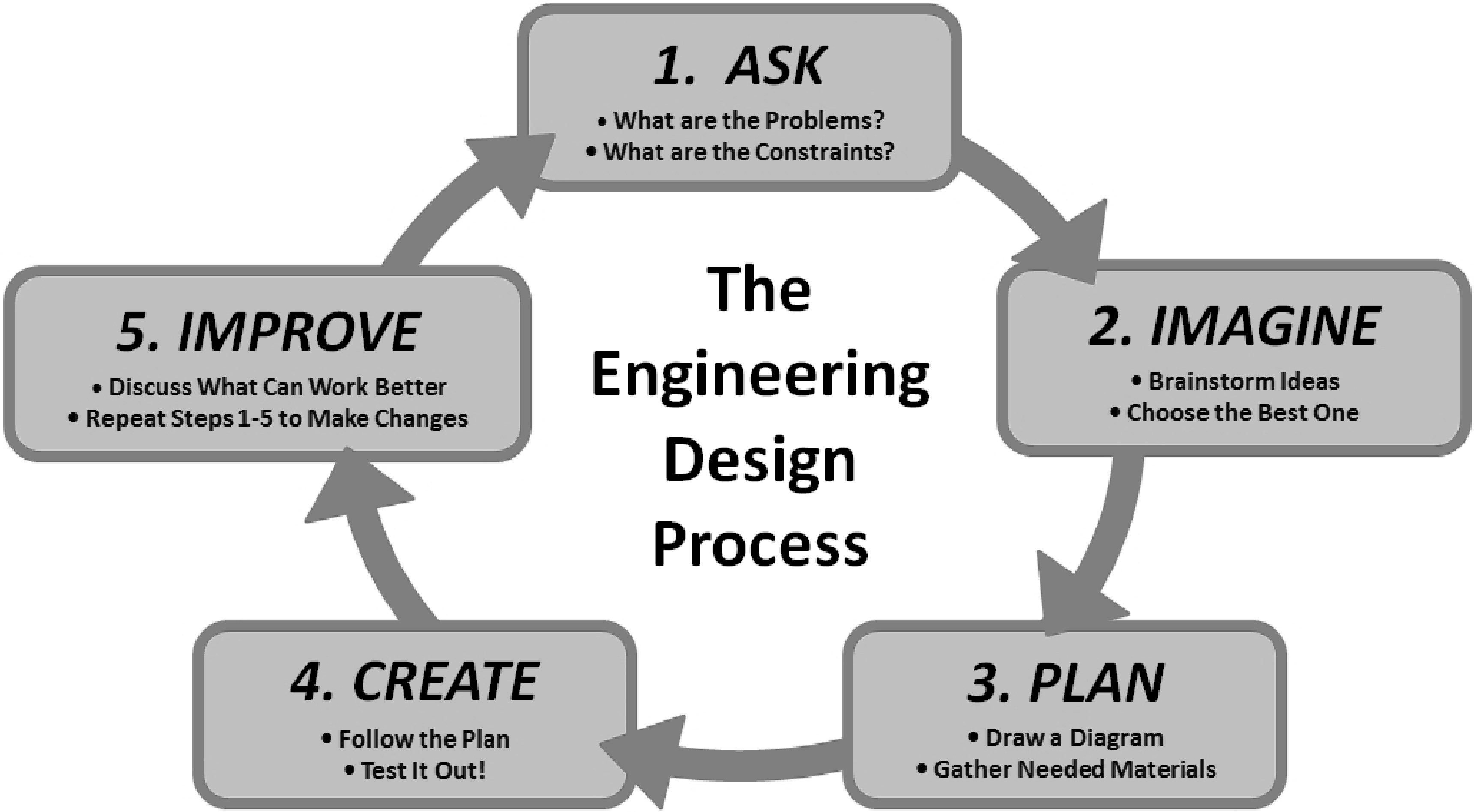
2. Why or why not?

3. How did your team work together today?

4. What could you personally do to better support your team?



Name ___________________________



http://www.engr.ncsu.edu/theengineeringplace/educators/k8plans.php

Name ___________________________________

Roller Coaster Challenge Letter

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SAUSD Common Core Lesson Planner Teacher:

<table>
<tr><td>Unit:
Roller Coaster Physics
Day: 9-13
Lesson: 6</td><td>Grade Level/Course:
Grade 8 Physical Science</td><td>Duration: 5 class periods
Date:</td></tr>
<tr><td colspan="3">Big Idea: Energy plays an important role in manufacturing design.
Essential Question – How do you use the engineering process to design and create a roller coaster that fits within budget and design specifications?</td></tr>
<tr><td>Common Core and Next Generation Science Standards</td><td colspan="2">NGSS: Performance Expectations
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

NGSS: Disciplinary Core Ideas
PS2.A: Forces and Motion
•For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
•The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
PS2.B: Types of Interactions</td></tr>
</table>

	•Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. **PS3.A: Definitions of Energy** •Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. •A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** •When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** •A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. •There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. •Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. •Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** •Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. •The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. **Reading Standards for Literacy in Science and Technical Subjects**: RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table) **Writing Standards for Literacy in Science and Technical Subjects**: WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience **Speaking and Listening Standards (ELA):**

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SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation
SL8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest</td></tr>
<tr><td>Materials/ Resources/ Lesson Preparation</td><td colspan="2">Paper Roller Coaster track print outs – 1 set per group of four
Paper Roller Coaster Instruction Manual – 1 per group of four
scotch tape – 1 roll per group of four
cardboard base – 1 per group of four
glass marble – 1 per group of four
scissors, ruler – 1 per student if possible (teacher/school provides)
TR 6.1 Paper Roller Coasters interactive PPT
SR 6.1 Roller Coaster Build Daily Journal
SR 6.2 RCP Model Guidelines
SR 6.3 RCP Proposal Guidelines
SR 6.4 RCP Design and Performance Score
SR 6.5 RCP Budget Analysis
SR 6.6 RCP Proposal Questions
SR 6.7 RCP Proposal Rubric</td></tr>
<tr><td>Objectives</td><td>Content:
Students will design and create a paper roller coaster following the engineering design process and incorporating the scientific principles of energy, forces and motion learned in this unit.</td><td>Language:
Students will complete a daily journal to assess their group's and personal progress.
Students will work collaboratively to create a written proposal to sell their roller coaster.</td></tr>
<tr><td>Depth of Knowledge Level</td><td colspan="2">☐ Level 1: Recall ☐ Level 2: Skill/Concept
☒ Level 3: Strategic Thinking ☒ Level 4: Extended Thinking</td></tr>
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<tr><td>TEACHER PROVIDES SIMPLE EXPLANATION:
proposal
budget</td><td></td></tr>
<tr><td>STUDENTS FIGURE OUT THE MEANING:
structure
performance</td><td></td></tr>
<tr><td>Pre-teaching Considerations</td><td colspan="2">Before the unit practice folding the pieces to the roller coaster so you are comfortable with the process. The interactive ppt will guide teacher/students through the first day lesson.
A set of pieces is provided for each team, but they do not have to use all of them – have extras on hand for those students that want to expand (keeping in mind they have “budget”).
Use trays or boxes to contain the materials (marble, tape, scissors, rulers, manual) for each group – check every class period to make sure all items are returned.
Students MUST be stingy with their use of tape – it is expensive and it doesn’t take large pieces or massive quantities to hold the track pieces together.
Determine where you will be storing the coasters and the parts for each table and each class – suggestions: designate a specific area for each class period, give each team a grocery bag to store their track pieces in.

NOTE: Use your judgment to gage effective use of time while students are building the roller coaster. Consider having team numbers on the white board and having students record their progress on the board at the end of each class period to hold students accountable.</td></tr>
<tr><td colspan="3">Lesson Delivery</td></tr>
<tr><td>Instructional Methods</td><td colspan="2">Check method(s) used in the lesson:
☒ Modeling ☒ Guided Practice ☒ Collaboration
☒ Independent Practice ☒ Guided Inquiry ☒ Reflection</td></tr>
<tr><td>Lesson Continuum — Lesson Opening</td><td colspan="2">Preparing the Learner
Prior Knowledge, Context, and Motivation:

1. Have students re-read the design challenge letter as an introduction to the Roller Coaster Project they will be working on for the next 7 days.</td></tr>
</table>

<table>
<tr>
<td>Lesson Continuum</td>
<td>Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding</td>
<td>
Interacting with the concept/text:
<u>DAY 9 Building the Roller Coaster (day 1 of the build)</u>
1. Go over the roller coaster model guidelines in the student workbook (SR 6.2). Then give a <u>brief</u> overview of the group project proposal (SR 6.3) and budget (SR 6.5). Suggest that students mainly think about the model today, and revisit the project proposal guidelines tomorrow.
2. Model the step by step building process for each of the following pieces with all of the students:
• Column
• Beam
• Straight track
• Curve
• Loop
• Diagonal support (not in ppt – have students follow in manual)
This will give teams a “stockpile” of pieces that they can use to start building. Structural pieces are white, track elements are in color. Watch for tape wastage!
3. You will also need to model for them how to attach a column to the base and use the diagonal support to create a strong, vertical support for their structure. The columns can also be “stacked” to create a taller structure and the beams with diagonal supports add to the strength and stability. The track pieces will be attached to this structure in various key locations and will weave in and around the structure.
Share with the students: The wonderful thing about this project is, if you build from the bottom up, you will always have a roller coaster that will work, assuming you are constantly testing and revising as you go (remember the Marshmallow Challenge!).
4. Allow teams to begin working. Teams will likely be trying different ideas. Circulate and remind teams to refer to the design process. You may want to use guiding questions such as:
What are the design constraints?
Are you planning to make a prototype?
Sketch ideas?
Make a blueprint before you start?
How do you plan to keep your coaster’s cost low, yet still exciting and fun?
</td>
<td>
Students Who Need Additional Support
• Cooperative groups for immediate feedback.
• Multiple opportunities to speak
• Collaborative hands on inquiry
• Journal writing reduces stress about sharing orally

Accelerated Learners:
• Reduce guided practice when students trying different structural ideas
• Peer grouping to deepen thinking and match pace
• Blue prints should be to scale and include measure-ments.
</td>
</tr>
</table>

Lesson Continuum	Activities/Tasks/ Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	1. 10 minutes before the end of the period, ask students to clean up and fill in the RC Build Daily Journal (SR 6.1). 2. Explain they will be making a reflection entry each day and go over the questions. Remind students they will be turning in this journal as part of the project assessment so be thoughtful. 3. To hold students accountable each day for progress, have one group member share with the class something that they have reflected on and/or what they are planning on starting with the following day. **<u>DAY 10 Building the Roller Coaster (day 2 of the build)</u>** 4. Revisit the project proposal and the various components they will need to include. Remind them of the deadline for finishing both their roller coaster and group project proposal and suggest that they design purposely with the proposal guidelines in mind. 5. Allow teams to start working. Circulate and remind teams to refer to the design process. Remind them to use their building instruction booklet if they have trouble constructing track pieces. Be sure to continue to ask teams questions to keep them focused. 6. With 10 minutes until the end of the period, ask students to clean up and fill in the daily journal (SR 6.1 7. To hold students accountable each day for progress, have one group member share with the class something that they have reflected on and/or what they are planning on starting with the following day. **<u>DAYS 11,12,13 Building the Roller Coaster (days 3,4,5 of the build)</u>** 8. Remind students about time management and that both the roller coaster and the group project proposal must be complete by the end of day 5. The group proposal can be finished up one of the following days, but they should start working on it by day 4. 9. Allow teams to start working. Circulate and remind teams to refer to the design process. Remind them to use their building instruction booklet if they have trouble constructing track pieces. Be sure to continue to ask teams questions to keep them focused.	

		1. With 10 minutes before the end of the period, ask students to clean up and fill in the daily journal (SR 6.1). 2. To hold students accountable each day for progress, have one group member share with the class something that they have reflected on and/or what they are planning on starting with the following day.	
Lesson Reflection			
Teacher Reflection Evidenced by Student Learning/ Outcomes			

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Paper Roller Coaster Project

Day 9

Building the Pieces

∗ You will only need to know how to make few pieces of track to construct a large roller coaster.

∗ We'll go through how to make some of the basic pieces that you'll need.

∗ After that, you're on your own to build any piece that you need.

Building the Framework

∗ Before you can start building your track, you need to build the structure that supports it.

∗ The structure is made of columns and beams that will attach to the cardboard base.

The Key

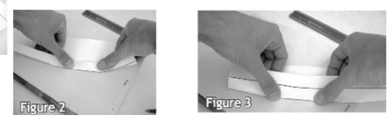
▪▪▪▪▪▪ Heavy dotted lines - trace, then fold

▬▬▬ Heavy solid lines - cut

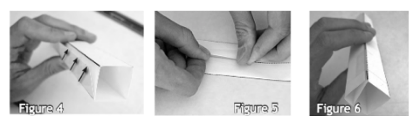
- - - - - - Thin dotted lines - cut or fold, if needed

Making Columns and Beams

Use a pen to score or dent the heavy dotted lines to make it easier to fold.



Each team has a manual that gives step by step instructions for each piece. You can also modify the pieces! Be creative!

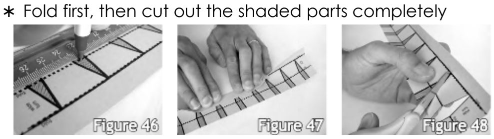


Making Straight Track

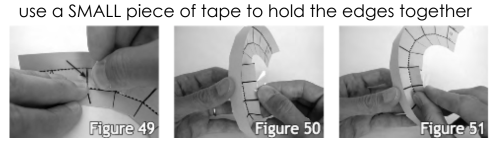
NOTE: Structural pieces are WHITE, track elements are IN COLOR

Making Curves

∗ Fold first, then cut out the shaded parts completely



∗ Bring the cut edges together so they are just touching – use a SMALL piece of tape to hold the edges together



Making Loops


Figure 70

Figure 71

Figure 72

Bring two flaps together so that the shaded pattern on one is just barely hidden - use a SMALL piece of tape to hold the edges together


Figure 73

Figure 74

Figure 75

Completing Loops

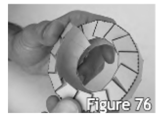
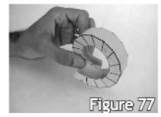


Figure 76

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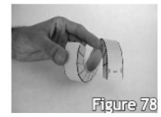
Figure 78

Making a Funnel and Other Track Elements

∗ Refer to your manual for additional pieces.

∗ Be creative! You can modify pieces! Be sure to TEST, TEST, and then TEST some more!

∗ Good Luck Engineers!

Name ___________________________________

Roller Coaster Build Daily Journal

Complete an entry for each day your team worked on building your roller coaster.

What did your group get done today?

Date: ____________

Are you happy with this progress?

What is something new that you tried?

Did it work like you expected?

What did you do to resolve it?

How did your team work together today?

What can you personally do to have your team work together better tomorrow?

What did your group get done today?

Date: ____________

Are you happy with this progress?

What is something new that you tried?

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Name ___________________________________

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Complete an entry for each day your team worked on building your roller coaster.

What did your group get done today? Date: ___________ Are you happy with this progress? What is something new that you tried? Did it work like you expected? What did you do to resolve it? How did your team work together today? What can you personally do to have your team work together better tomorrow?
What did your group get done today? Date: ___________ Are you happy with this progress? What is something new that you tried? Did it work like you expected? What did you do to resolve it? How did your team work together today? What can you personally do to have your team work together better tomorrow?

Name ___________________________________

Roller Coaster Build Daily Journal

Complete an entry for each day your team worked on building your roller coaster.

What did your group get done today?

Date: ___________

Are you happy with this progress?

What is something new that you tried?

Did it work like you expected?

What did you do to resolve it?

How did your team work together today?

What can you personally do to have your team work together better tomorrow?

What did your group get done today?

Date: ___________

Are you happy with this progress?

What is something new that you tried?

Did it work like you expected?

What did you do to resolve it?

How did your team work together today?

What can you personally do to have your team work together better tomorrow?

Name ___________________________________

Roller Coaster Project

Model Guidelines

INTRODUCTION AND OBJECTIVES

Six Flags has issued a challenge to roller coaster designers to determine who should build their next roller coaster. You'll need to prove that you can make a model of an exciting roller coaster that meets their requirements, using as little money as possible.

EQUIPMENT NEEDED

- Paper Roller Coasters instruction manual
- Paper Roller Coaster pieces on card stock
- scissors
- tape
- cardboard base
- marble
- ruler

OBJECTIVE

The amusement park wants your roller coaster to have the following requirements:

1. Total track length must be 150 cm or longer
2. At least one loop
3. At least 6 turns
4. Safety – your marble must travel down the roller coaster smoothly without flying off the track

The following elements will help your chances of having your roller coaster chosen:

1. Uphill portions
2. Longer ride time

PROCEDURE

While trying to spend as little "money" as possible, build a Paper Roller Coaster using the supplies that your teacher provides. The roller coaster should be exciting, reliable, safe, and take a long time for the marble to travel from the start to the finish. You may want to look at the rubric and budget analysis forms before you begin. Good luck!

Name ___________________________________

Roller Coaster Project

Proposal Guidelines

Step 1: Create a title page that will include:

- The name of your coaster
- A visual representation of your theme (This may include pictures, specialized font, colors that represent your coaster)
- Your design team name
- The names of each of your team members

Step 2: Blueprint/Pictures

- Include at least 2 blueprint drawings or color photographs that clearly illustrate your roller coaster's components
- You must include the following labels on your blueprint or photos
  - Greatest Potential Energy
  - Greatest Kinetic Energy
  - A place where G Force is greater than 1
  - A place where G Force is less than 1
  - A place where acceleration is occurring
  - A place where deceleration is occurring

Step 3: Budget Analysis

- Complete the budget analysis sheet

Step 4: Design and Performance Score

- Complete all of the calculations on the data sheet

Step 5: Written Proposal Questions

- Complete the written questions. Be sure to answer in complete sentences and paragraphs.

Name ___________________________________

Roller Coaster Project

Budget Analysis

Type of Piece	Cost per Piece	Number of Pieces	Total Cost
Column	$ .50	x	
Straight track	$1.00	x	
Beam	$ .50	x	
Diagonal support	$1.00	x	
Sharp turn	$1.25	x	
Wide turn	$1.25	x	
Shelf	$ .05	x	
Funnel	$2.50	x	
Loop	$1.50	x	
Total Price:			

Name ___________________________________

Roller Coaster Project

Design and Performance Data and Score Sheet

Height of Coaster

____

Total Track Distance

____

Design Cost

____

Time Trials

(if the marble falls off the track or stops, record that trial as a zero)

1. ___________
2. ___________
3. ___________
4. ___________
5. ___________

Total Time: ________

Average Speed

Take the distance of the track and divide it by the fastest time (smallest number).

Show your work!

$s = d \div t$

Category	Points
Total time (5 trials) each second = 1 point	
Track length > 150 cm? (10 points)	
At least 1 loop? (10 points)	
At least 6 turns? (10 points)	
Uphill sections (5 points for each section of track where the marble goes uphill)	
Total Construction Score	
Cost of Materials ($1 = 1 point) (Subtract from Construction Score)	−
Final score (Total Construction Score − Cost of Materials)	

Name ___________________________________

Roller Coaster Project

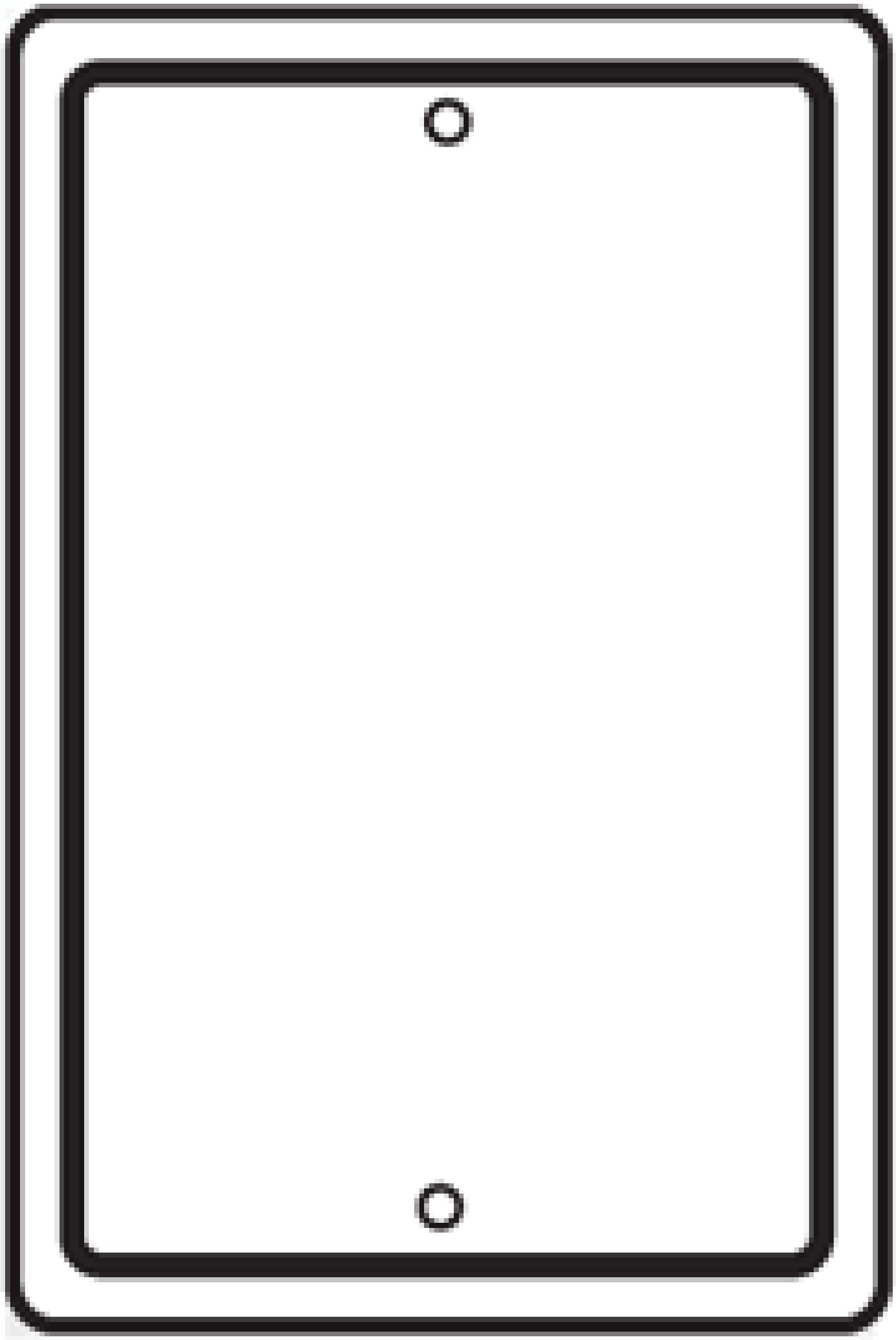
Proposal Questions

1. What makes your ride special? Walk us through the components of your coaster that create the most thrilling ride.

2. Why should Six Flags accept your proposal? (Consider the entire package, theme, thrill level, safety, consideration of the scientific forces, length of ride, speed, etc…)

Name ___________________________________

3. Create a warning sign that states all of the safety concerns that someone will need to consider before riding your ride.



Name ___________________________________

Roller Coaster Project

Proposal Rubric

Component	Point Value	Your Points
Title Page	5	
Blue Prints/Pictures	15	
Design and Performance Score	50	
Budget Analysis	15	
Written Proposal	15	
Total Project Score:	***100***	

SAUSD Common Core Lesson Planner **Teacher:**

Unit: **Roller Coaster Physics** **Days: 14-15** **Lesson: 7**	**Grade Level/Course:** Grade 8 Physical Science	**Duration: 2 class periods** **Date:**
Big Idea: When designing a roller coaster, engineers must consider many different scientific principles. **Essential Question:** What is the evidence that your roller coaster met the specifications of the challenge?		
Common Core and Next Generation Science Standards	**NGSS: Performance Expectations** **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. **NGSS: Disciplinary Core Ideas** **ETS1.A: Defining and Delimiting Engineering Problems** •The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** •A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. •There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. •Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. •Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** •Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. •The iterative process of testing the most promising solutions and modifying	

	what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. **Reading Standards for Literacy in Science and Technical Subjects**: RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks **Writing Standards for Literacy in Science and Technical Subjects**: WHST.6-8.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience **Speaking and Listening Standards (ELA):** SL.8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly SL.8.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation SL8.5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest	
Materials/ Resources/ Lesson Preparation	Have the following materials ready for teams to test their projects Timers – time to travel down the track Sting – to determine length of track Meter sticks Calculators – for budget calculations	
Objectives	**Content:** Students will be able to create a design proposal that includes the data from their coaster, budget analysis, blueprints and persuasive writing	**Language:** Students will cite evidence in the extended anticipatory guide. Students will write persuasively in the proposal
Depth of Knowledge Level	☒ **Level 1: Recall** ☒ **Level 2: Skill/Concept** ☐ **Level 3: Strategic Thinking** ☒ **Level 4: Extended Thinking**	
College and Career Ready Skills	☒ **Demonstrating independence** ☒ **Building strong content knowledge** ☒ **Responding to varying demands of audience, task, purpose, and discipline** ☒ **Comprehending as well as critiquing** ☒ **Valuing evidence** ☐ **Using technology and digital media strategically and capably** ☐ **Coming to understand other perspectives and cultures**	

<table>
<tr><td>Common Core Instructional Shifts</td><td colspan="2">☒ Building knowledge through content-rich nonfiction texts
☒ Reading and writing grounded from text
☒ Regular practice with complex text and its academic vocabulary</td></tr>
<tr><td rowspan="3">Academic Vocabulary (Tier II & Tier III)</td><td>KEY WORDS ESSENTIAL TO UNDERSTANDING</td><td>WORDS WORTH KNOWING</td></tr>
<tr><td>TEACHER PROVIDES SIMPLE EXPLANATION: peer review
evaluate</td><td>docent</td></tr>
<tr><td>STUDENTS FIGURE OUT THE MEANING:</td><td></td></tr>
<tr><td>Pre-teaching Considerations</td><td colspan="2">Look over the Roller Coaster Rubric and adjust the points as needed for your class. Point values listed are just a suggestion.</td></tr>
<tr><td colspan="3">Lesson Delivery</td></tr>
<tr><td>Instructional Method</td><td colspan="2">Check method(s) used in the lesson:
☐ Modeling ☐ Guided Practice ☒ Collaboration
☐ Independent Practice ☐ Guided Inquiry ☒ Reflection</td></tr>
<tr><td>Lesson Continuum — Lesson Opening</td><td colspan="2">Preparing the Learner
Prior Knowledge, Context, and Motivation:

1. Have students turn to their Extended Anticipatory Guide (SR 1.2) from the first day of the unit.
2. Direct students to complete day 14 columns. This will be turned to count as a portion of their final assessment. Students are NOT to change their day 1 checkmarks!!
3. Give student ~15 minutes to read through, answer and fill in the evidence section. The evidence can come from their notes, readings or handouts.
4. The teacher may invite students to collaborate with an elbow partner or their team OR the teacher can decide if this is an individual effort.</td></tr>
</table>

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding	**Interacting with the concept/text:** **<u>DAY 14 – Project Proposal</u>** 1. Students should work in their teams to complete all aspects of their project proposal. 2. They will need to finish their test calculations 3. Teacher should be circulating and guiding teams through the process of completing their proposals with are DUE TOMORROW. 4. Groups will turn in 1 proposal for their team including all 5 components (refer to SR 6.3): • Title Page • Blueprint/Pictures • Budget Analysis • Design/Performance Data and Score Sheet • Proposal Questions Models without proposals will not be scored. **<u>DAY 15 – Peer Review</u>** 1. Ask all of the teams to look at their Peer Review form in their handbook (SR 7.1). Explain that they will be traveling from coaster to coaster in a gallery walk to view each design. 2. Go over what the scoring guidelines should be: • A 5 is the best: Explain WHY. • When scoring construction quality, consider the precision of the folds, structural integrity and the difficulty of the design elements. When scoring excitement value, consider the loops, turns, speed, length of ride and other components that make a ride exciting. **NOTE**: Be sure to model scoring a roller coaster (chose one from another class) to ensure students understand the meaning of the terms they are evaluating, such as "precision of folds, structural integrity"…etc. 3. Each team will pick a docent to stay with their model to present it to the other teams as they walk through. The docent should be the only person who touches the coaster and runs the marble down to show off their coaster.	**Students Who Need Additional Support** • Group work to provide brainstorming and immediate support • Teacher proximity for immediate support • Collaborative interactive and hands on work • Model scoring process to explain work meaning **Accelerated Learners:** • Create blue print to scale with measurements listed in cm. • Represent the team as the docent

Lesson Continuum	Activities/Tasks/Strategies/Technology/ Questioning/Engagement/Writing/Checking for Understanding		
		4. Teams will travel from table to table every 2 minutes. Before moving on, they should record the name, construction and excitement level for the coaster on their Peer Review sheet (SR 7.1) 5. After viewing all of the coasters, teams should return to their table and share with their docent their findings. The team will then choose the best coaster OTHER THAN THEIR OWN based on the scores they recorded. 6. Have each team vote for the best coaster overall. Collect votes and announce the winner. Ask teams to describe what made that coaster the best. 7. The teacher can offer extra credit or other prize to the winning team as they see fit. The teacher can also create additional categories for voting (longest ride, most thrills, neatest coaster, most creative, etc) 8. You may want to take the winning design from each period and have a competition for best class design. Best school design? Challenge another school!? 9. Students should turn in their team proposal. Teacher needs to decide how to score individual components – extended anticipatory guide (SR 1.2), daily journals (SR 6.1)…collect? Score as circulate room? 10. The coasters will make an awesome Open House display if you can figure out how to store them until that time! ***Well done Engineers!***	

Lesson Reflection

Teacher Reflection Evidenced by Student Learning/ Outcomes	

Name ___________________________________

Roller Coaster Project

Peer Review

Instructions: Rate the other coasters on a scale of 1-5, where a 5 is the best score possible. When scoring construction quality, consider the precision of the folds, and the difficulty of the design elements. When scoring excitement value, consider the

Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____
Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____
Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____
Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____	Name of Coaster: Construction Value _____ Excitement Value _____
Favorite Roller Coaster (Other than your own!)		

loops, turns, speed, length of ride and other components that make a ride exciting.

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